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OF THE
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TENTATIVE STANDARDS

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SUMMARY OF THE PROCEEDINGS OF THE TWENTY-THIRD ANNUAL MEETING.

ASBURY PARK, N. J., JUNE 22–25, 1920.

THE TWENTY-THIRD ANNUAL MEETING OF THE AMERICAN SOCIETY FOR TESTING MATERIALS was held at the New Monterey Hotel, Asbury Park, N. J., June 22–25, 1920. The following is an analysis of attendance at the meeting: Members in attendance or represented, 589; guests, 133; total, 722; ladies, 143. The corresponding statistics for the Twenty-second Annual Meeting are : Members in attendance or represented, 560; guests, 133; total, 693; ladies, 174.

FIRST SESSION—TUESDAY, JUNE 22, 10 A. M.

On Non-Ferrous Metals and Metallography.

President J. A. Capp in the chair.

The minutes of the Twenty-second Annual Meeting were approved as printed.

The President appointed A. W. Carpenter and Frank Zeleny as tellers to canvass the vote for officers.

The report of Committee B-2 on Non-Ferrous Metals and Alloys was presented by its chairman, William Campbell. On successive motions of Mr. Campbell, the following action was taken with respect to the recommendations in the report of the committee:

The proposed revisions in the Tentative Specifications for Lead (B 29 – 19 T) were approved, and the specifications as thus revised continued as tentative.

The proposed Tentative Specifications for Sheet High Brass were accepted for publication as a tentative standard of the Society.

The proposed revision in the Standard Specifications for

Copper Bars for Locomotive Staybolts (B 12 – 18) was accepted for publication as tentative for one year.

The proposed revisions in the Tentative Methods for Chemical Analysis of Alloys of Lead, Tin, Antimony and Copper (B 18 – 17 T) were approved, and the methods as thus revised continued as tentative.

The Tentative Methods for Battery Assay of Copper (B 34 – 19 T) and the Tentative Methods for Chemical Analysis of Pig Lead (B 35 – 19 T) were referred to letter ballot of the Society for adoption as standard, after proper changes in style to conform to other A.S.T.M. methods.

The proposed Tentative Specifications for Aluminum for Use in the Manufacture of Iron and Steel were accepted for publication as a tentative standard of the Society.

The proposed revisions in the Tentative Specifications for Aluminum Ingots for Remelting and for Rolling (B 24 – 19 T) were approved, and the specifications as thus revised continued as tentative.

The recommendation of the committee that the Method for Analysis of Spelter, which is now included in the Standard Specifications for Spelter (B 6 – 18) be given a new serial number and published separately under methods of analysis, after re-writing to conform to the style of other A.S.T.M. methods, was, on motion, approved, with the understanding that this recommendation can not be put into effect until the next edition of the Book of A.S.T.M. Standards is printed.

After considerable discussion, the report of the committee dealing with the subject of Nomenclature of Non-Ferrous Alloys was, on motion, accepted for publication in the Proceedings. The recommendation that this report be transmitted to the British Institute of Metals in order to bring it to their attention for criticism and comment, was referred to the Executive Committee.

The report of Committee E-4 on Magnification Scales for Micrographs was then presented by its chairman, W. H. Bassett.

On motion of Mr. Bassett, the proposed revisions in the Tentative Definitions and Rules Governing the Preparation of Micrographs of Metals and Alloys (E 2 – 19 T), were approved and the Definitions and Rules, as thus revised, were referred to letter ballot of the Society for adoption as standard. The recommendation of the committee that copies of these Rules, if adopted as standard, should be sent to other scientific societies in this country and abroad for their consideration, was referred to the Executive Committee.

Mr. Bassett called attention to the change in title of Committee E-4 to "Committee on Metallography," and to the recommendation to the Executive Committee that a Standing Committee on Pyrometry be formed.

The following papers were then presented by their authors, and discussed:

"A Note on the Constitution of Certain Tin-Bearing Brasses," by William Campbell;

"Fatigue and Impact Fatigue Tests of Aluminum Alloys," by W. A. Gibson.

The tellers on the vote for election of officers presented their report, and in accordance therewith the President announced the election of the following officers:

For President, to serve for one year: George S. Webster.

For Vice-President, to serve for two years: George K. Burgess.

For Members of Executive Committee, to serve for two years: L. G. Blackmer, D. E. Douty, Prevost Hubbard, R. S. Whiting.

The President stated that the President-elect had been unavoidably detained from the meeting, and requested Past-Presidents G. H. Clamer and A. A. Stevenson to escort the Vice-President-elect to the chair. Mr. Burgess expressed his appreciation of the honor of being elected to the Vice-Presidency of the Society, which he considered not merely a personal honor but one as well to the institution, the Bureau of Standards, which he represents, and pledged the heartiest cooperation of the Bureau in aiding the work and furthering the ideals of the Society.

The meeting then adjourned till 3 P. M.

SECOND SESSION—TUESDAY, JUNE 22, 3 P. M.

On Wrought and Malleable Iron and Corrosion.

President J. A. Capp in the chair.

The President stated that the President-elect, G. S. Webster, was present, and requested Past-Presidents G. H. Clamer and A. A. Stevenson to escort him to the platform. Mr. Webster expressed his appreciation of the honor of being the President of the Society. He referred to the growth in membership and activity, and expressed his hope that the coming year would be one of greater success and achievement than ever before.

The report of Committee A-2 on Wrought Iron was presented by its chairman, H. E. Smith. On motion of Mr. Smith, the proposed revisions in the Standard Specifications for Welded Wrought-Iron Pipe (A 72 – 18) and the proposed revisions in the Standard Specifications for Staybolt Iron (A 39 – 18) were accepted for publication as tentative for one year.

On motion of Mr. Smith, the proposed Tentative Definitions of Terms Relating to Wrought-Iron Specifications were accepted for publication as a tentative standard of the Society.

The report of Committee A-5 on Corrosion of Iron and Steel was presented by its chairman, S. S. Voorhees. At Mr. Voorhees' request, the reports of the following three sub-committees of Committee A-5 were presented by their respective chairmen:

Report of Sub-Committee II on Preservative Metallic Coatings for Metals, G. K. Burgess, chairman;

Report of Sub-Committee III on Inspection of the Fort Sheridan, Pittsburgh and Annapolis Tests, J. H. Gibboney, chairman;

Report of Sub-Committee V on Immersion Tests, W. A. Cooper, chairman.

A paper entitled "A New Method of Testing Galvanized Coatings" was presented by its author, Allerton S. Cushman, and discussed. The method of testing described in this paper was demonstrated by H. E. Brooks.

In the absence of the author, a paper on "Effect of Machining and of Cross-Section on the Tensile Properties of Malleable Cast Iron," by H. A. Schwartz, was read by title.

A paper on the subject "Chain Cable and Some of Its Physical Properties," by C. G. Lutts, was presented by the author, and discussed.

The meeting then adjourned till 8 P. M.

THIRD SESSION—TUESDAY, JUNE 22, 8 P. M.

Presidential Address and Reports of Administrative Committees.

Past-President A. A. Stevenson in the chair.

President J. A. Capp read the annual presidential address.

Following the presentation of this address, the Secretary-Treasurer took occasion to call the attention of the members present to the fact that the presiding officer of this session holds the distinction of having served continuously as an executive officer of the Society longer than any member within recent years. After referring to his election nine years ago as a member of the Executive Committee, on which he has served continuously since that time successively as Member, Vice-President, President and Past-President, and stating that at the meeting of the Executive Committee on the next day would be brought to a close the extremely able, willing and self-sacrificing services that he has rendered to the Society as a member of that committee, the Secretary-Treasurer offered the following Resolution, which was unanimously adopted by a rising vote:

> "*Whereas*, the American Society for Testing Materials, assembled at its Twenty-third Annual Meeting, has noted that its honored Past-President, A. A. Stevenson, brings to a close with this Annual Meeting nine years of continuous and active service as a member of the Executive Committee; and
>
> "*Whereas*, the Society desires to make fitting recognition at this time of those services; therefore be it
>
> "*Resolved*, that the American Society for Testing Materials expresses its appreciation of the able and wise counsel and self-sacrificing services that Mr. Stevenson has rendered as an executive officer of the Society."

The Secretary-Treasurer then presented the annual report of the Executive Committee, calling attention briefly to the outstanding features of the report, including the financial statement, the very gratifying growth of membership, the increased activities of the standing committees, and particularly a number of important matters relating to A.S.T.M. committee affairs and the joint activities of the Society with other organizations.

On motion, the report of the Executive Committee was accepted.

The report of Committee E-5 on Standing Committees was then presented by its chairman, C. L. Warwick, and on motion accepted.

The report of Committee E-6 on Papers and Publications was then introduced by C. L. Warwick, chairman. The recommendation of the committee that the standing committees of the Society be requested to move their Spring meetings forward one month wherever possible, in order to give greater time for the editing and printing of committee reports prior to the annual meeting, was referred to the Executive Committee.

On motion, the report was accepted.

The meeting then adjourned, and was followed by an informal dance and smoker.

FOURTH SESSION—WEDNESDAY, JUNE 23, 10 A. M.

On Steel.

Vice-President C. D. Young in the chair.

The report of Committee A-1 on Steel was presented by its chairman, F. M. Waring. In presenting the report, Mr. Waring stated that a meeting of the committee had been held Monday afternoon, June 21, at which it had been unanimously voted to withdraw the recommendation, contained in the report as preprinted, relating to a proposed revision of the tables of permissible variations of plates ordered to weight and to thickness, appearing in seven standard specifications of the Society.

On motion of Mr. Waring, the report of the committee as thus revised was accepted, involving the following action with respect to the recommendations contained in the report:

The proposed revisions in the following standard specifications were accepted for publication as tentative for one year:

For Quenched High-Carbon-Steel Splice Bars (A 49 – 15);
For Quenched Carbon-Steel Track Bolts (A 50 – 16);

For Quenched Alloy-Steel Track Bolts (A 51 – 16);
For Steel Screw Spikes (A 66 – 18);
For Structural Steel for Bridges (A 7 – 16);
For Structural Nickel Steel (A 8 – 16);
For Structural Steel for Buildings (A 9 – 16);
For Structural Steel for Locomotives (A 10 – 16);
For Structural Steel for Cars (A 11 – 16);
For Rivet Steel for Ships (A 13 – 14);
For Boiler Rivet Steel (A 31 – 14);
For Lap-Welded and Seamless Steel Boiler Tubes for Locomotives (A 28 – 18);
For Welded Steel Pipe (A 53 – 18);
For Automobile Carbon and Alloy Steels (A 29 – 18).

The proposed revisions in the following tentative standards were approved, and the specifications as thus revised continued as tentative:

For Steel Tie Plates (A 67 – 18 T);
For Low-Carbon-Steel Track Bolts (A 76 – 18 T);
For Steel Plates for Forge Welding (A 78 – 19 T);
For Carbon Tool Steel (A 71 – 17 T);
For Electric Cast Steel Anchor Chain (A 77 – 18 T).

The proposed Tentative Specifications for Commercial Bar Steels were accepted for publication as a tentative standard of the Society.

Mr. Waring stated that at its meeting on Monday afternoon, the committee had considered the question of the continuance or removal of the note that still remains on fourteen standard and tentative specifications of the Society, by which the rejection limits for sulfur in all steels and for phosphorus in acid steels is raised 0.01 per cent above the values given in the specifications. The committee was of the opinion that the conditions in the steel industry which led to the continuation of this note at the last annual meeting have not improved in the past year, and accordingly recommended that the consideration of the removal of the note from these specifications, which are listed below, be again deferred until the annual meeting in 1921:

Standard Specifications for:

Carbon-Steel Rails (A 1 – 14);
Low-Carbon-Steel Splice Bars (A 3 – 14);

Structural Steel for Buildings (A 9 – 16);
Structural Steel for Locomotives (A 10 – 16);
Structural Steel for Cars (A 11 – 16);
Structural Steel for Ships (A 12 – 16);
Rivet Steel for Ships (A 13 – 14);
Billet-Steel Concrete Reinforcement Bars (A 15 – 14);
Steel Castings (A 27 – 16);
Lap-Welded and Seamless Steel Boiler Tubes for Locomotives (A 28 – 18);
Lap-Welded and Seamless Steel and Wrought-Iron Boiler Tubes for Stationary Service (A 52 – 18);
Iron and Steel Chain (A 56 – 18).

Tentative Specifications for:

Steel Tie Plates (A 67 – 18 T);
Low-Carbon-Steel Track Bolts (A 76 – 18 T).

On motion of Mr. Waring this recommendation was approved.

Mr. Waring called special attention to two important features of the report: The cooperative work with the Mechanical Section of the American Railroad Association on Specifications for Steel Castings for Railroads, and the progress that has been made in the work of the Joint Committee on Investigation of Phosphorus and Sulfur in Steel, upon which some ten national organizations and Government departments, including the A.S.T.M., are represented.

The report of Committee A-8 on Magnetic Analysis was then introduced by its chairman, C. W. Burrows, and on motion of Mr. Burrows was accepted.

A paper by G. W. Sargent entitled "Molybdenum as an Alloying Element in Structural Steels" was then presented by its author, and discussed.

In the absence of the author, Mr. James E. Howard, a paper entitled "On the Shattered Zones in Certain Steel Rails, with Notes on the Interior Origin of Transverse Fissures" was presented in abstract by the Secretary-Treasurer, and discussed.

The Secretary-Treasurer presented in summarized form a paper by Henry M. Howe and Edward C. Groesbeck entitled "A Note on Stresses Caused by Cold Rolling," which was then discussed.

The meeting then adjourned till 8 P. M.

FIFTH SESSION—WEDNESDAY, JUNE 23, 8 P. M.

On Testing Apparatus.

Vice-President G. K. Burgess in the chair.

The chair recognized President J. A. Capp, who stated that he desired to make an important announcement on behalf of the Executive Committee.

The President called attention to the statement in the annual report of the Executive Committee, presented at the Tuesday evening session, that there had been held in Washington on June 3 and 4, under the auspices of the Joint Conference Committee of the four Founder Societies, an Organizing Conference consisting of representatives of national, local, state and regional engineering and allied technical organizations throughout the entire country, for the purpose of considering forming a federation of such organizations that would be broadly representative of the engineering profession in non-technical matters and in matters of public welfare in which the engineer is concerned. The Society was represented at this conference by three delegates: its President-elect, G. S. Webster, its Vice-President, C. D. Young, and its Vice-President-elect, G. K. Burgess, whose report on the Organizing Conference was considered by the Executive Committee at its meeting that afternoon. The outcome of the conference was the agreement that there should be formed such a comprehensive organization, to be known as The Federated American Engineering Societies; and a Constitution and By-Laws were adopted by the Organizing Conference as a basis upon which to proceed ultimately with the organization of the Federation.

The President explained that the Executive Committee has been in close sympathetic touch with this important movement. There has not, however, been time in the few weeks since the conference was held for the matter to receive full and complete consideration by the Executive Committee; nor has there been opportunity to prepare an adequate statement for presentation to the members of the Society at this annual meeting upon which discussion of the project could be based. The President accordingly advised the members that at its meeting that afternoon the Executive Committee had voted to continue its delegates to the Organizing Conference as a special committee on this subject, with directions to inform the membership of the Society by circular letter, in as complete detail as possible, of the purpose of The Federated American Engineering Societies and of the obligations resulting from participation by the Society in the activities of the Federation. The proposed Constitution and By-laws as they are finally drafted will be included in this statement. The committee has also been authorized to conduct a questionnaire of the members of the Society for the purpose of ascertaining as nearly as may be possible by such means the sentiment of the membership towards the participation of the Society in the movement.

A paper on the subject of "A High-Speed Alternating Torsion Testing Machine," by D. J. McAdam, Jr., was presented by its author and discussed.

A paper entitled "Improved Elastic Limit Recorder," by C. H. Marshall, was, in the absence of the author, presented in abstract by the Secretary-Treasurer.

A paper under the joint authorship of J. L. Jones and C. H. Marshall entitled "A New Method for Calibrating Brinell Hardness Testing Machines" was presented by Mr. Jones, and discussed.

The following papers were then introduced by their respective authors:

"Ductility Testing Machines," by Thorsten Y. Olsen;
"A New Type of Automatic Cement Tester," by Thorsten Y. Olsen;
"An Apparatus for Delicate Flexure Tests and Some Results of Such Tests," by W. J. Francke.

The meeting then adjourned till the following morning.

SIXTH SESSION—THURSDAY, JUNE 24, 10 A. M.

On Preservative Coatings and Lubricants.

Mr. G. B. Heckel in the chair.

The report of Committee D-1 on Preservative Coatings for Structural Materials was presented by its chairman, P. H. Walker. On motion of Mr. Walker, the proposed revisions in the Standard Specifications for Purity of Raw Tung Oil (D 12 - 16) were accepted for publication as tentative for one year.

On further motion of Mr. Walker, the proposed revision of the Standard Specifications for Turpentine (D 13 - 15), in the form of revised specifications, was accepted for publication as a tentative standard of the Society.

In the absence of the chairman, C. P. Van Gundy, the report of Committee D-2 on Lubricants was presented by the vice-chairman, P. H. Conradson. On motion of Mr. Conradson the proposed revisions in the Tentative Test for Viscosity of Lubricants (D 47 - 19 T) were approved, and the test as thus revised was referred to letter ballot of the Society for adoption as standard.

A discussion of the report of Sub-Committee V on Emulsification was then presented.

The chair called attention to the recent enlargement of Committee D-2 into a Committee on Petroleum Products and Lubricants.

The following three papers were presented by their respective authors, and discussed:

"Further Development of the Plastometer and Its Practical Application to Research and Routine Problems," by Henry Green;

"An Instrument for Measuring the Hiding Power of Paints," by R. L. Hallett;

"A New Colorimeter for White Pigments and Some Results Obtained by Its Use," by A. H. Pfund.

The meeting then adjourned till 3 P. M.

SEVENTH SESSION—THURSDAY, JUNE 24, 3 P. M.

Miscellaneous Reports and Papers.

Mr. D. E. Douty in the chair.

The report of Committee D-7 on Timber was presented by its chairman, Hermann von Schrenk. On successive motions of Mr. von Schrenk, the following action was taken with respect to the recommendations contained in the report:

The Tentative Specifications for Southern Yellow-Pine

Timber to be Creosoted (D 24 – 15 T), and the Tentative Specifications for Southern Yellow-Pine Piles and Poles to be Creosoted (D 25 – 15 T) were referred to letter ballot of the Society for adoption as standard.

The proposed revisions in the Tentative Specifications for Wooden Paving Blocks for Exposed Pavements (D 52 – 18 T) were approved, and the specifications as thus revised were referred to letter ballot of the Society for adoption as standard.

The proposed Tentative Specifications for Structural Douglas Fir, designed to supersede the present Tentative Specifications for Selected Structural Douglas Fir Bridge and Trestle Timbers (D 23 – 16 T), were accepted for publication as a tentative standard of the Society.

A paper on "The Uses and Properties of Water-resistant Plywood," by Armin Elmendorf, was then presented by its author.

The report of Committee D-10 on Shipping Containers was introduced by its chairman, J. A. Newlin. On motion of Mr. Newlin, the proposed Tentative General Specifications for Wooden Boxes, Nailed and Lock-Corner Construction, were accepted for publication as a tentative standard of the Society.

On motion of Mr. Newlin, the recommendation of the committee that the Tentative Specifications for Canned Foods Boxes, Nailed and Lock-Corner Construction (D 44 – 17 T) be withdrawn and the proposed Tentative Specifications for Wooden Boxes, Nailed and Lock-Corner Construction, for the Shipment of Canned Foods, be substituted and published as a tentative standard of the Society, was approved.

The report of Committee D-11 on Rubber Products was presented by its chairman, E. A. Barrier. On motion of Mr. Barrier, the following tentative specifications were referred to letter ballot of the Society for adoption as standard:

For Leader Hose for Use with Pneumatic Tools (D 60 – 19 T);
For Steam Hose (D 54 – 18 T);
For Rubber Belting for Power Transmission (D 53 – 19 T).

The proposed Tentative Specifications for Adhesive Insulating Tape were accepted for publication as a tentative standard of the Society.

The report of Committee D-6 on Coke was presented by its chairman, Richard Moldenke. On motion of Mr. Moldenke, the proposed revision in the Standard Methods for Laboratory Sampling and Analysis of Coke (D 37 – 18) was accepted for publication as tentative for one year.

Mr. J. M. Bierer then read a paper on the subject "Construction of Steam Hose."

The report of Committee D-13 on Textile Materials was, in the absence of its chairman, G. B. Haven, presented by A. E. Jury, vice-chairman. On motion of Mr. Jury, the Tentative General Methods for Testing Cotton Fabrics (D 39 – 19 T) were referred to letter ballot of the Society for adoption as standard.

On further motion of Mr. Jury, the proposed Tentative Methods for Testing Textiles were accepted for publication as a tentative standard of the Society.

In the absence of the chairman, S. W. Parr, the report of Committee D-3 on Methods of Sampling and Analysis of Coal was presented by A. C. Fieldner. On motion of Mr. Fieldner, the proposed revision in the Standard Methods for Laboratory Sampling and Analysis of Coal (D 22 – 16) was accepted for publication as tentative for one year.

The meeting then adjourned till 8 P. M.

EIGHTH SESSION—THURSDAY, JUNE 24, 8 P. M.

On Ceramics, Lime and Gypsum.

President-elect G. S. Webster in the chair.

The report of Committee C-3 on Brick was, in the absence of its chairman, Edward Orton, Jr., presented by the secretary, A. V. Bleininger. On motion of Mr. Bleininger the proposed revision in the Tentative Specifications for Building Brick (C 21 – 19 T) was approved, and the specifications as thus revised were referred to letter ballot of the Society for adoption as standard.

The report of Committee C-4 on Clay and Cement Sewer Pipe was presented by its vice-chairman, A. J. Provost, in the absence of the chairman, Rudolph Hering. On motion of Mr. Provost the revisions in the Tentative Specifications for Clay

Sewer Pipe (C 13 – 18 T) and in the Tentative Specifications for Cement-Concrete Sewer Pipe (C 14 – 19 T), proposed in the report as preprinted, were approved. Mr. Provost then stated that the committee, at a meeting held during the annual meeting, had voted to recommend certain additional minor revisions designed to provide requirements for a new size of pipe, 4 in. in diameter.[1]

Mr. Provost explained that there had not been opportunity to refer these later revisions to letter ballot of the committee, but that such a ballot would be conducted immediately after the annual meeting. On motion of Mr. Provost, this revision was approved subject to subsequent approval on letter ballot vote of the committee.[2]

The two specifications as thus revised were then referred to letter ballot of the Society for adoption as standard.

The report of Committee C-6 on Drain Tile was presented by its vice-chairman, A. N. Talbot, in the absence of the chairman, Anson Marston. On motion of Mr. Talbot, the proposed revisions in the Standard Specifications for Drain Tile (C 4 – 16) were accepted for publication as tentative for one year.

The report of Committee C-8 on Refractories was then introduced by its chairman, A. V. Bleininger. On successive motions of Mr. Bleininger, the following action was taken with respect to the recommendations in the report:

The following tentative standards were referred to letter ballot of the Society for adoption as standard:

Tentative Test for Softening Point of Fire-Clay Brick (C 24 – 19 T);
Tentative Methods for Ultimate Chemical Analysis of Refractory Materials (C 18 – 18 T);
Tentative Test for Porosity and Permanent Volume Changes in Refractory Materials (C 20 – 18 T);
Tentative Test for Refractory Materials under Load at High Temperatures (C 16 – 18 T), with the addition of two explanatory footnotes, as recommended;
Tentative Definitions for Clay Refractories (C 27 – 19 T).

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[1] These revisions appear in detail on pp. 266–267.

[2] These revisions have subsequently been unanimously approved by letter ballot vote of the committee.—ED.

The proposed Tentative Method for Ultimate Chemical Analysis of Chrome Ores and Chrome Brick was accepted for publication as a tentative standard of the Society.

At the request of Mr. Bleininger, R. M. Howe of Mellon Institute presented in abstract a paper on the subject "Vital Factors in the Testing of Fire-Clay Refractories and in the Interpretation of Results." On motion of Mr. Bleininger, this paper was accepted for publication as an appendix to the report of Committee C-8.

A paper on "Testing of Porosity of Electrical Porcelain" was presented by its author, W. D. A. Peaslee.

The report of Committee C-7 on Lime was then introduced by its chairman, D. K. Boyd, and on motion accepted.

The report of Committee C-11 on Gypsum was then presented by its chairman, W. E. Emley. The report contained revisions, in the form of new specifications and methods, of the following tentative standards:

Tentative Specifications for Gypsum (C 22 – 19 T);
Tentative Specifications for Calcined Gypsum (C 23 – 19 T);
Tentative Methods for Tests of Gypsum and Gypsum Products (C 26 – 19 T).

Mr. Emley stated that the committee had subsequently adopted a number of minor revisions in these specifications and presented them in full. On motion of Mr. Emley, these revised specifications and methods were accepted for publication as tentative standards of the Society, to supersede the existing tentative standards.

On motion of Mr. Emley, the proposed Tentative Specifications for Gypsum Plasters, with certain modifications subsequently adopted by the committee, were accepted for publication as a tentative standard of the Society.

The meeting then adjourned till the following morning.

NINTH SESSION—FRIDAY, JUNE 25, 10 A. M.

On Road Materials.

Past-President A. N. Talbot in the chair.

A paper entitled "The So-Called Asphalt Content of Road Oils," by B. A. Anderton and D. G. Taylor, was presented by Mr. Anderton, and discussed.

A paper entitled "Some Relations Between the Characteristics of Steam-Distilled Petroleum Residuals" was then presented by the author, B. A. Anderton.

The report of Committee D-4 on Road Materials was presented by its chairman, A. H. Blanchard. On successive motions of Mr. Blanchard, the following action was taken with respect to the recommendations in the report of the committee:

The following tentative standards were referred to letter ballot for adoption as standard:

Tentative Test for Loss on Heating of Oil and Asphaltic Compounds (D 6 – 19 T);
Tentative Method for Determination of Softening Point of Tar Products (Cube-in-Water Method) (D 61 – 19 T);
Tentative Specifications for Materials for Cement Grout Filler for Brick and Stone Block Pavements (D 57 – 19 T);
Tentative Specifications for Materials for Cement Mortar Bed for Brick, Stone Block and Wood Block Pavements (D 58 – 19 T).

The following proposed tentative tests, methods and specifications were accepted for publication as tentative standards of the Society:

Tentative Test for Specific Gravity of Road Oils, Road Tars, Asphalt Cements and Soft Tar Pitches;
Tentative Test for Specific Gravity of Asphalts and Tar Pitches Sufficiently Solid to be Handled in Fragments;
Tentative Test for Quantity of Clay and Silt in Gravel for Highway Construction;

Tentative Test for Quantity of Clay in Sand-Clay, Top-soil, and Semi-Gravel for Highway Construction;
Tentative Test for Quantity of Clay and Silt in Sand for Highway Construction;
Tentative Methods for Sampling of Stone, Slag, Gravel, Sand and Stone Block for Use as Highway Materials, including Some Material Survey Methods;
Tentative Specifications for Commercial Sizes of Broken Stone and Broken Slag for Highway Construction;
Tentative Specifications for Commercial Sizes of Sand and Gravel for Highway Construction;
Tentative Specifications for Broken Slag for Waterbound Base;
Tentative Specifications for Shovel-Run or Crusher-Run Broken Slag for Waterbound Base;
Tentative Specifications for Natural or Artificial Sand-Clay Mixtures for Highway Surfacing.

Mr. Blanchard then stated that the proposed Tentative Specifications for Consistency of Concrete for Highway Construction, as submitted in the preprint copy of the report, had been modified by the committee as to form, without change in substance, and that the title had been changed to "Tentative Specifications for Workability of Concrete for Concrete Pavements." Mr. Blanchard moved that these specifications as revised be accepted for publication as a tentative standard of the Society. This motion was discussed by Richard L. Humphrey, who moved that these specifications be not published as tentative but referred back to Committee D-4 with instructions to the committee to confer with other committees of the Society interested in the specifications, namely, Committees C-2 on Reinforced Concrete and C-9 on Concrete and Concrete Aggregates. Following some further discussion, the substitute motion was put to a vote and lost, the vote being 10 affirmative, 40 negative.

Mr. Blanchard's original motion was then carried by a vote of 39 affirmative, 9 negative. The specifications as modified by the committee were therefore accepted for publication as a tentative standard.

Mr. Blanchard then stated that Committee D-4 desired to withdraw the proposed Tentative Specifications for Proportions for Concrete for Highway Construction, which were recommended in its report (as preprinted) for acceptance as a tentative standard, and desired to recommend instead that the essential information and recommendations contained in these specifications be published as Appendix II to its report, under the title "Proportions for Concrete for Highway Construction."

Mr. Humphrey moved that the proposed specifications be referred back to Committee D-4 for conference with Committees C-2 and C-9, without publication in the Proceedings. After considerable discussion this motion was lost, a division not being called for.

There then followed some discussion of the manner in which the data in the proposed appendix should be published, and the suggestion was made that the question of form of publication be referred to the Committee on Papers and Publications. Accordingly Mr. Blanchard moved that the data and recommendations now contained in the proposed Tentative Specifications for Proportions for Concrete for Highway Construction be published as Appendix II to the report under the title "Proportions for Concrete for Highway Construction," and that the question of form and arrangement of this appendix be referred to Committee E-6 on Papers and Publications. This motion was carried.

The following papers were then presented by their respective authors, and discussed:

"The Standard Deval Abrasion Test for Rock," by F. H. Jackson;

"Impact Test on Concrete to Regulate Coarse and Fine Aggregate Qualities and Mixes for Highways," by H. S. Mattimore.

The meeting then adjourned till 8 P. M.

TENTH SESSION—FRIDAY, JUNE 25, 8 P. M.

On Cement and Concrete.

President J. A. Capp in the chair.

The chair called for the report of the Golf Tournament Committee, E. D. Boyer, chairman. Mr. Boyer stated that the Fourth Annual A.S.T.M. Golf Tournament had been held that afternoon with entire success, and on behalf of the committee he awarded the following prizes:

For Low Score for the Course:

The American Society for Testing Materials Championship Cup and medal: Clarence Hall, Washington, D. C.

For the Lowest Net Score:

First Prize............	H. L. Sherman, Boston, Mass.
Second Prize...........	E. D. Boyer, New York City.
Third Prize.............	F. G. Breyer, Palmerton, Pa.

For the winner of the "Blind Handicap":

A silver cup..........	A. A. Somerville, New York City.

The report of Committee C-1 on Cement was then presented by its chairman, R. S. Greenman. On motion of Mr. Greenman, the recommendation of the committee that the Standard Specifications and Tests for Portland Cement (C 9 – 17) be revised by the omission of Section 36 on Permissible Variations in Fineness, was approved, and the proposed revision was referred to letter ballot of the Society, with the understanding that if adopted it would become effective January 1, 1921.

Mr. Greenman also recommended on behalf of the committee that Section 52 of the specifications be amended so as to indicate that the price of standard Ottawa sand is three instead of two cents per pound. On motion of Mr. Greenman, this recommendation was approved and referred to letter ballot, also to become effective if adopted on January 1, 1921.

The report of Committee C-2 on Reinforced Concrete was then introduced by Richard L. Humphrey, chairman, and on his motion accepted for publication.

In the absence of the chairman, Sanford E. Thompson, the report of Committee C-9 on Concrete and Concrete Aggregates was presented by the secretary, A. T. Goldbeck. On motion of Mr. Goldbeck, the following tests and methods were accepted for publication as tentative standards of the Society:

Tentative Methods for Making and Storing Specimens of Concrete in the Field;
Tentative Test for Unit Weight of Aggregate for Cement Concrete;
Tentative Method for Determination of Voids in Fine Aggregate for Cement Concrete.

A paper by G. M. Williams entitled "Some Determinations of the Stress-Deformation Relations for Concretes Under Repeated and Continuous Loadings" was, in the absence of Mr. Williams, presented by W. A. Slater, and discussed.

The following papers were then presented by their respective authors, and discussed:

"Effect of Hydrated Lime and Other Powdered Admixtures in Concrete," by D. A. Abrams;
"Effect of Rodding Concrete," by F. E. Giesecke.

A paper by R. B. Young and W. D. Walcott entitled "The Volume-Moisture Relation in Sand and a Method of Determining Surface Area Based Thereon" was then read by Mr. Young.

The presentation of this paper concluded the regular order of business and the chair asked if there was any miscellaneous business. The Secretary-Treasurer announced the final attendance at the meeting[1] and pointed out that on the basis of the present membership (2760), the registration would indicate that one out of every five of the members had attended this annual meeting.

The Secretary-Treasurer also referred to the many courtesies that had been extended to the members individually and to the Society as such by the management of the New Monterey

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[1] See page 9.

Hotel, and to the hearty spirit of cooperation that had been manifested in arranging for the many details of the meeting. On his motion, a vote of thanks and appreciation to the management of the hotel was unanimously adopted.

On motion of D. K. Boyd, a vote of thanks was extended to the retiring officers and to the Secretary-Treasurer and his staff for their work during the past year, particularly in connection with the arrangements for the annual meeting.

There being no further business, President Capp then declared the meeting of the American Society for Testing Materials adjourned *sine die.*

AMERICAN SOCIETY FOR TESTING MATERIALS.

ORGANIZED IN 1898.
INCORPORATED IN 1902.

PROCEEDINGS.

The Society is not responsible, as a body, for the statements and opinions advanced in this publication.

ANNUAL ADDRESS BY THE PRESIDENT, J. A. CAPP.

June 22, 1920.

Through established custom, the retiring presiding officer of our Society is expected to speak at the annual meeting. One can hardly call it singing his swan song, because the rule under which he continues a member of the Executive Committee for three years tends very largely to overcome the criticism which is sometimes voiced against those who have been honored by election to office, that upon retirement at the end of their term, they drop off into inactivity. The addresses to which we have listened with pleasure and profit have generally been formal and accepted as the expression of personal views, because discussion, such as is invited after presentation of other papers and reports, is not expected. To-night, you will not listen to a formal address, but rather to a talk about the growth of the work done in and by the Society, and our responsibilities, as members, for the furtherance and guidance of the growth in the future for which we look with confidence as the proper fulfilment of the aims for which we have associated ourselves together.

Everyone but his family and close associates realizes the growth of a boy from infancy to manhood. That realization often comes to the family with considerable shock; they have been vaguely aware of increasing stature and filling out of breadth and girth, have even derived amusement from the change from boyish treble to the sturdier tones of approaching manhood; but the large significance of the change often fails to impress them because it has come so gradually and naturally under their very noses. Thrice fortunate is that youth whose growth has been sympathetically realized and guided so that not only has he attained his height and breadth well rounded out in physical strength and vigor, but his mind has kept pace with his body and has also rounded out in well-balanced proportions. Such a man keeps on growing even after mere increase in height has ceased, and unless he falls into evil ways or is stopped by accident or illness, expands in wisdom and usefulness, and in authority of utterance, even until in the fulness of years he is gathered to his fathers.

Associations of men are much like the individuals making them and necessarily take on the character of the members. Beginning in a small way with a comparatively small body of men associated together, the society grows or dies according to whether its avowed objects are worthy and the members keep the character of the society in a high plane and see to it that reasonable effort is made to accomplish the proper purposes for which it was formed. That there are notable exceptions to this general rule may be looked upon as the equivalent of the growth of children in an unhealthy or even criminal environment, which children so often seem to be fully as sturdy as those more wholesomely placed. With the passing of years, the healthy society grows in physical size through the acquisition of members, and its utterances gain in weight as their worth is proved by their wisdom.

In the case of individuals, account is taken of the passing years and the annual recurrence of birthdays is celebrated. On reaching his twenty-first birthday, the youth is considered to have reached the full state of manhood, and to be prepared to begin the assumption of all the responsibilities which that entails. We may not push our analogy too far nor take an illustration too literally, but we may well look on the annual meetings of societies as the celebration of its birthday. This is the twenty-third annual meeting of the American Society for Testing Materials; it has rounded out twenty-two years of busy life and none may gainsay its healthy growth both in physical size and in influence. It came into being with avowed objects and its founders were men of broad vision who saw the need of cultivation of the rather special field which they selected. They and those who have followed have given much of themselves to the careful nurturing of the body which they created. It has suffered no mushroom growth, and surely we who are privileged to hold membership are warranted in the belief that our Society has attained to full stature of manhood, well rounded out in physical and mental vigor. Right here, our analogy falls down flat in one important particular. The individual practically ceases physical growth on reaching manhood, save perhaps by an undesirable increase in corpulency by the acquisition of relatively useless and possibly even harmful tissue; he remains for a number of years practically stationary until with the approach to his full span of life, he may even shrink. Ultimately he passes on and is no more. Not so with associations or societies formed by these individuals; if they serve a useful purpose and maintain their proper place in the world of men, they must continue to grow indefinitely by acquisition of new members. No one may say that there need be any limit to the natural life of a healthy body of men, whatever the limit may be to that of the individual members of the body.

Its parents or guardians are responsible for the growth and development of a child; the members of a society are equally responsible for its growth and development. As the parent who tries to meet his responsibility must take stock of progress from time to time and make his plans for the future, so must we, members of a society, pause to review the past, take stock of the present and plan for the future.

Our Executive Committee from time to time appeals to us to influence desirable men to join our Society. They have never suggested a definite campaign of increasing membership because mere addition of numbers may only be equivalent to the acquirement of undue corpulency by the individual, the taking on of something neither useful nor ornamental, which only impedes his movements and the getting rid of which causes him physical discomfort and perhaps even spiritual anguish. Our Society must continue to grow. Expenses ever are increasing and the need for more funds to meet them is always pressing. But of even greater importance is the necessity for greater resources to provide for the expansion of the work which we must make if we are to continue to meet the healthy demand made upon us to take up new problems and to reach out further into the field of engineering materials, the scientific cultivation of which we have assumed as our prerogative and duty. The legitimate and most desirable way to provide these increased funds is by increased numbers paying their quota. We cannot stress too strongly the sense of personal responsibility which should be felt by each of us as members for providing for the future by interesting desirable men and institutions in our work and inducing them to join in it. The young men starting on their career as materials engineers or experts especially should be sought and interested, because only by the infusion of new blood into our veins can we hope to maintain our virility and avoid the pessimism which comes from stagnation. So, too, in this way only can we provide for the continuation of work, for there must be younger men ready to fill the ranks as the older men find the pressure of other duties so great that continued activity in society affairs, and especially in committee service, becomes increasingly more difficult. The report of our Executive Committee as presented by the Secretary shows an encouraging increase in our membership during the past year; let us each make it our business to see to it that the figures for next year are enormously better. It should be our aim to have in our membership everyone who by reason of interest in and work with engineering materials is qualified to assume the responsibilities that membership implies.

In the charter of the American Society for Testing Materials it is stated that "the corporation is formed for the Promotion of Knowledge of the Materials of Engineering, and the Standardization of Specifications and the Methods of Testing." Our founders appear to have divided the field which they selected rather sharply into two sections or divisions. That the two sections are closely interrelated is evident; in fact, one may say that successful cultivation of one section may not be expected until after the reaping of crops from the other. Standardization of specifications for materials before a reasonable knowledge of those materials has been obtained is patently absurd and this knowledge may only have been acquired through development and application of methods of testing which, in turn, must have been so commonly used that investigators may understand the recorded results of others and compare them with their own. Yet our founders had good reason to define two sections in the field of our Society's work. While all standardization is founded upon knowledge of materials it does not follow that all the knowledge of materials which we may acquire leads necessarily to the formulation of specifications, nor even to standardization of methods of testing. Members of our Society participate in its activities both individually, by reading and discussing papers, and collectively, by active committee work. The technical papers are contributions to knowledge of materials and those closely following committee work will agree that committee activities are largely, and in many cases exclusively, in the standardization of specifications or of methods of testing.

Beginning in 1914, the proceedings have been issued in two volumes, one containing the technical papers and discussions, and the other given over to committee reports and proceedings. It is recognized that the number of pages in a volume is no criterion of the worth of the book nor of the amount of work done in its writing, yet it is interesting to note that the six volumes of papers contained some 3500 pages while there were some 3800 pages in the volumes of reports and proceedings.

From the record of pages published, one might feel warranted, then, in saying that the Society cultivates about equally the two divisions of its field. Yet it is a fact that the technical papers advancing our knowledge of materials are the published results of work done by individuals and the discussions are by individuals, while committee reports are the result of cooperative or collective work by larger or smaller groups of members associated as committees. From this, the conclusion may be drawn that the members of our Society devote themselves, so far as active participation in its affairs is concerned, largely to standardization rather than to the promotion of knowledge. Individually, many, if not actually the major portion of our members are very active in experimental investigation designed to yield fundamental information, and thanks are due the large number of those who contribute the knowledge so gained to the general good by freely publishing the results of their investigations. But, so far as the Society is concerned, we might say that the promotion of knowledge in this manner is accidental, while the standardization work is deliberately planned and systematically carried out.

No time need be spent in arguing for or against the desirability of establishing standards. Last year, President Clamer ably discussed this subject, and the perilous times through which we have recently passed have taught us the great value of standardizing. There is, in fact, a great wave of effort to unite in standardizing work passing over not only this country but practically over the civilized world. The American Engineering Standards Committee has gotten into its stride and rapid progress is being made both in organizing for work on proper lines of cooperation among the bodies in this country which have heretofore carried on their efforts more or less independently, and for concurrent work with other countries. Whatever may be the opinion of some who pessimistically believe that standardization will retard progress, we must recognize the fact that the day of standardization is here. We need have no fear of stopping progress. So long as human beings are richly endowed with curiosity and with a desire to learn and excel, progress will be made in all fields of human endeavor. No amount of fixing of rules will stop man trying the effect of breaking rules or of making new ones to cover new conditions. No standards can continue to hold in the face of newly developed qualities or materials which can be shown to be improvements upon those previously fixed.

Our Society was one of the first if not actually the first technical society having as one of its avowed objects standardization. It is obvious that we must continue the work which has been going on for twenty-two years, and it should be the earnest desire of every one of our members that we should continue to hold the leading position in standardization in our field, which we have earned and merited by an enviable record of achievement. In the beginning, we were forced to work alone on many problems because there were none upon whom we could call for help or with whom we could cooperate. Conditions have been changing during the past several years, and to an increasing extent the formation of joint committees has been possible. Our Executive Committee long ago adopted the broad policy of securing cooperation with other societies whenever they are ready to work with us, realizing that the more completely all the various interests are represented in formulating a standard, the stronger that standard is and the greater are its chances of universal adoption and use. We participated in the movement to organize the American Engineering Standards Committee because we felt the need of some supervising body which would formulate rules under which acceptable standards could be prepared and offered to the public with confidence. It speaks well for the foresight and care with which the rules governing the technical committees of our Society were drawn to be able to say that the rules adopted by the American Engineering Standards Committee differ in no essential requirement from those of our Society. The Standards Committee is a going concern and our Society has been honored by the election of one of our Past-Presidents as its chairman for this the first year of actual work as a committee. We have submitted to the Standards Committee a number of our specifications and methods of testing for their approval as Tentative American Standards or as American Standards, and the list of our existing standards is being gone over very carefully to prepare for the submission of others at the proper time. It is clearly the expectation that all standards adopted by our Society will ultimately be submitted to and approved by this Committee as American Standards. The extent to which this expectation will increase the number of cooperative or joint committees which we must organize and the extent to which we must share responsibility by becoming joint sponsors with other societies for certain standards may not yet even be predicted. Our technical committees should have ever before them the fact that it is far easier to gain the agreement of other bodies to accept a standard if they are consulted while it is being arrived at than it is after the standard is fully worked out. It is largely a matter of psychology. The ideas of two men may be substantially alike, but if one states his ideas concretely and asks the other to endorse the statement, an argument is apt to follow and disagreement result; whereas if the argument in a friendly and helpful spirit precedes and leads to the statement of ideas, both are well satisfied, and the chances are that the statement so arrived at will differ in no essential particular from that which either would have made independently. Our rules provide adequately for cooperation with other bodies and our Executive Committee may be trusted, as in the past, to work with our technical committees in putting into effect whatever of joint work becomes necessary because of our membership in the American Engineering Standards Committee.

We may say that our Society is engaged in very intensive cultivation of that portion of our field the crops from which are standard specifications and methods of testing. But are we cultivating as intensively the other half of our field? Is there the same careful, definite planning of the promotion of knowledge of materials on a broad comprehensive scale? Is there not a very human tendency merely to take what are currently accepted as the working qualities of commonly used materials about which a great deal is known and formulate specifications covering these materials? Such is the obvious thing to do when it is considered that specifications are for commercial use in buying and selling, and that there is no incentive to make specifications for materials which are not in extensive use. But we may easily fall into—or worse yet, perpetuate—error when we merely adopt currently accepted working qualities as standard. Do we spend enough time and thought in determining whether these currently accepted qualities are really those we ought to have or whether we should go against tradition and demand others? Mankind is possessed of a great deal of inertia, and tends strongly to resist change. When it has become the custom to apply a certain set of tests to estimate the quality of a certain material, we are very apt to keep on using these same tests, changing only the numerical values expected, even when progress in manufacture has gone so far that the material itself has changed almost radically in its qualities. When new materials are developed, we are apt to apply tests which have customarily been applied to other materials of a more or less similar nature, and if the results are not too glaringly bad, we are prone to continue these tests, even though a moderate amount of study would show that the new material is just enough different from those which we have been accustomed to testing to require considerable revision of our testing methods to develop the qualities of the new material concerning which we must have accurate knowledge. Obviously, these remarks apply more specifically to what are usually called physical tests, but which might properly be called mechanical tests.

The revision of the organization and scope of Committee E-1 on Methods of Testing is designed to provide the means by which a more intensive study of methods of mechanical testing may be made possible. It is the hope of the speaker that as the result of the new scheme of working of this committee our technical committees generally will start as intensive cultivation of the field of methods of testing as they have of the field of specifications. The development of one should parallel and keep pace with the other.

The broadening of the scope of Committee E-1 may be expected to result in a marked advance in our work on methods of testing, and certainly more highly developed methods of testing will provide us with the means of increasing our knowledge of materials. But this does not give us more than a partial answer to the question, "Is our Society doing all it can do as a society to promote knowledge of materials?"

The making of specifications presupposes a knowledge of the materials covered. None who have had the privilege of participating in committee activities will ever have any other impression than that of a wide knowledge of materials among the committee members. In fact, that is why they are members. It is a safe statement that the issue of each set of specifications makes a distinct and definite step forward in our knowledge of materials. For, after all, specifications are nothing but concrete statements of necessary or desirable qualities and of the means to be used in determining and measuring these qualities. The fact that specifications have been agreed upon with substantial unanimity by the committee members is proof that the commercially recognized qualities of the material covered have become sufficiently well known and established to permit a concrete statement of them.

If this be accepted, then we may say that by promulgating standard specifications and standard methods of testing, we are definitely advancing knowledge of materials. But we have said in discussing the division of our field into two sections—one, standards and the other, knowledge—that it does not follow that all the knowledge of materials which we may acquire leads necessarily to the formulation of standards. In fact, the intelligent application and use of materials in engineering construction requires a much wider and more intimate knowledge of the properties and characteristics of materials than is implied in the quantitative statement of a few salient qualities included in the specifications.

The real user of engineering materials is the designing engineer who must make a definite selection of the material to be used in the fabrication of each part of his design. He must base this selection upon facts which may be listed under three headings—Cost, Availability and Suitability. Market conditions supply the matter to be placed under cost and availability, while under suitability must be included all of the knowledge of the materials which he can gather together. He must have not only the control properties commonly specified, but also data on such questions as reliability and duplication and on the special qualifications which must be possessed in order that the part in question may render the service demanded of it. The development of modern engineering practice has made necessary a much more intimate knowledge of the general and special properties of materials than was formerly required and there has grown into existence among engineers a class of specialists on materials. In the recent attempts to classify engineers for Government service, this class of experts or specialists has been recognized by the inclusion of a class to be known as Materials Engineers. It is to the Materials Engineer, then, that the designer must look for all of that which he must have in order intelligently to select his materials on the basis of suitability. Perhaps we have found a new name for ourselves, for it is certain that the great majority of the members of our Society will be found to qualify as Materials Engineers.

Professor Talbot, in 1914, selected as the title to his Presidential address "The Relation between Research and the Activities of the Society," and made a most earnest plea for the inclusion of research upon materials in the scheme of committee work. In 1918, the entire fifth session at the annual meeting was devoted to a topical discussion on Cooperation in Industrial Research. Within the past several years, research has grown into great prominence; industrial concerns and the engineering colleges have established research laboratories on an extensive scale. During the war, the National Research Council came into being. Everywhere about us, there is a great activity in intensive study of industrial and engineering problems by men whose time is entirely given up to such study. What would be more fitting than for the American Society for Testing Materials to assume a leading part in fostering and directing research on materials, just as we lead in the standardizing of specifications for materials and of the methods of testing them?

Excellent work is already being done by our committees, many of which have carried out extensive researches. Others have researches under way and still others have plans in progress. In fact, some of our committees have taken up problems which, so far, appear to be primarily research. With them the standardization of methods of test has been incidental, and the development of specifications seems far in the future. Yet, notwithstanding a very considerable activity in research work among our committees, it appears to be a fact that many of our most active committees devote their energies almost exclusively to standardization of specifications and only take up research when a special problem in their work on specifications confronts them which requires special study for its solution. This is entirely right and proper so long as the making of specifications is the real business of the committee. But it is apparent that with the issue of specifications the supplying of knowledge of the usefulness of materials has only begun.

The designer presents a concrete problem, he wants to know what material he should use in a certain part and why. The listing of properties as determined by tests, even including many sorts of tests not usually made in routine inspection, is not a sufficient answer, because it is not usually possible to say in any quantitative sense what influence any given property has upon the useful life of the material in a specific application. For example, experience has taught us that unless steel has at least a certain percentage of elongation and reduction of area in a tension test, it is too "short" for certain purposes, but would it be twice as good for the same purposes, if, strength and elastic limit remaining the same, steel could be provided with twice the percentage of elongation? In the airplane and automobile, aluminum alloys have been used for many parts, replacing copper alloys and even steel. Yet it is well known that the ductility of aluminum alloys, as measured by percentage of elongation in a tensile test, is only one-half to one-fourth that of the copper alloys or of steel.

It is not necessary to multiply examples. We have all had the difficulty of making it clear to the designer why the facts concerning one material do not necessarily bear any direct relation to similar facts concerning another material when considering the applicability of these materials in construction. The questions asked by the designer must be answered and in most cases, the answer is possible only by long explanations and discussions which lead to a decision based upon inferences drawn from experience and backed up by judgment. This process has sometimes been called "educated guessing," and that so much of engineering is based upon inference and judgment is simply because the demand for knowledge has grown so much more rapidly than the supply.

The demand was recognized when, twenty-three years ago, our Society was organized. The first problem to be attacked was obviously that of standardizing the commonly available materials and the methods of testing them. To that problem our committees have addressed themselves and the results have been of inestimable value. The work will never be completed because new materials are constantly being developed and old materials improved as methods of manufacture are bettered. There will never come a time when there need no longer be committees whose main business is the formulation of specifications.

That we have begun to catch up with this part of our work is indicated by the degree of stability that is given to our specifications since we began publishing our Book of Standards every three years instead of permitting revision every year. This suggests a question which merits serious consideration—is not the time ripe for undertaking the second part of our work through the same type of organization which has been proved so efficient in standardization?

Put in another way, we may say that the first and most obvious thing to do, when our committees were first organized, was to attempt to put in order and classify the available facts about the materials on which tests had commonly been made. From this, the next step was standardization, both of methods of testing and of the results to be expected when materials are tested by the established methods. With this accomplished, we have the means of knowing whether our materials are good or bad of their kind and even of comparing them one with another in a scale of reasonable accuracy. Is not the next step, the determination of what our materials are good for and why?

We know the conditions to be met in service by any structural part and we know many of the useful properties of materials. Must we not now address ourselves to the solution of the problem "on what properties does the suitability of a material for particular applications depend and how may these properties be used to measure suitability"?

The problem is not one for the user or producer alone; rather it is one for both to attack in the same helpfully cooperative spirit that has been developed in our committees on specifications. The different viewpoint of consumer and producer is, in itself, a help, and the knowledge and experience of both are needed to provide a true perspective.

There is no more profitable field for committee work and it is one obviously within the boundaries set and described by our founders in their application for a charter. If we do not actively cultivate this field through committee work and every other sort of society activity, are we doing all we should do for "the Promotion of Knowledge of Engineering Materials"?

ANNUAL REPORT OF THE EXECUTIVE COMMITTEE.

Publications.—The regular publications issued last year were the Proceedings, Membership List, and Supplement to Book of A.S.T.M. Standards. The 1919 Proceedings are the largest in volume in the history of the Society. A comparative statement as to the volume of regular publications during the past three years is exhibited in the following:

	1917 Pages.	1918 Pages.	1919 Pages.
Proceedings	1550	1244	1601
Book of A.S.T.M. Standards	....	908	....
Membership List	251	297	298
Supplement to Book of Standards	41	....	63
Total	1842	2449	1962

In pursuance of action taken at the 1918 annual meeting, the Book of A.S.T.M. Standards is now issued triennially. The last edition (1918) contains 128 standards adopted by the Society at the time of its publication, and was supplemented in 1919 by a pamphlet containing ten standards adopted that year. Such proposed new standards as may be adopted by letter ballot following this annual meeting will be issued in a separate pamphlet, of which every member will receive a copy. The next edition of the Book of Standards will appear in 1921 and will contain under a single cover all of the standards of the Society adopted up to that time.

In addition to the "regular publications" the Society has again published during the past year, in accordance with the policy adopted in 1917, a Book of A.S.T.M. Tentative Standards (350 pp.). The 63 Tentative Standards of the Society which appear in Part I of the 1919 Proceedings are published in this separate volume, which is placed on sale for the convenience of those desiring the tentative standards in a single book.

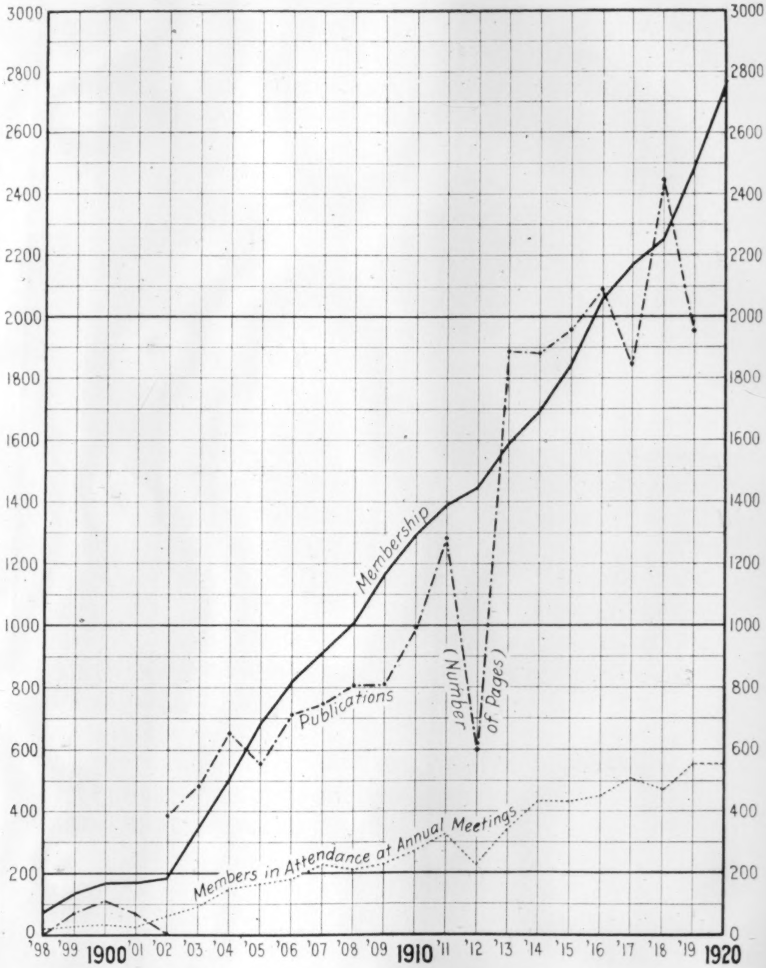
Eleven circulars to members aggregating 52 pages have also been issued during the past year.

Membership.—The membership at the last annual meeting was 2481. Since then 440 applications for membership have been approved as compared with 391 during the previous year. The losses by death number 10, namely:

Carnegie, Andrew	August 11, 1919
Carpenter, R. C.	January 19, 1919
Drew, Harry	July 2, 1919
Enright, Bernard	April 4, 1920
Hildreth, P. S.	April 1, 1919
King, M. L.	October 23, 1919
Love, E. G.	September 12, 1919
Nelson, E. D.	February 18, 1920
Royce, A. C.	February 6, 1920
Sillman, Joseph	February 15, 1919

The number of resignations is 92 and 65 members have been dropped for non-payment of dues, the former being 4 less and the latter 15 more than for the previous year. The total losses for the year from all causes number 167, and the net increase in membership for the year is 273, as compared with 220 for the previous year. The total membership of the Society is now 2754, of whom 257 are Junior Members.

During the past year, the Executive Committee has made special efforts to stimulate the growth of membership in the Society along sound, healthy lines. Each member of the Executive Committee is personally endeavoring to secure not less than five new members during this year, and a number of them have already done so. The members of the Society have had the question of membership increase kept constantly before them through circular letters accompanied by application blanks for membership, which the members have been asked to place in the hands of persons who would be interested in the work of the Society. On April 21, the Secretary-Treasurer addressed personal letters to the 785 members of the Society who hold membership on the standing committees, explaining to them that the Executive Committee wishes especially to enlist their aid in securing desirable new members. Each member addressed was asked to secure at least two new members this year and was furnished for that purpose with two application blanks and booklets of information. Finally, the Secretary-Treasurer has lost no opportunity of bringing in a dignified way the advantages



NOTE.—The initial curve for publications (1898–1902) refers to the publications of the American Section of the International Association for Testing Materials. The marked drop for 1912 in the "publications" and "members in attendance at annual meetings" curves is due to the fact that the Sixth Congress of the International Association was held in New York in September, 1912, and that the activities of the American Society for that year were accordingly restricted to committee reports and administrative business. The drops of the "publications" curve in 1917 and 1919 are explained by the fact that the Book of A.S.T.M. Standards was not published those years.

of membership in the Society to the attention of individuals and firms who might be expected to be interested in the Society's activities. The very gratifying result of these efforts is seen the fact that for the first five months of this year there were added to the membership 243 new members, compared to 192 for the corresponding period last year, which in turn was larger than for any previous corresponding period. Again, the result of the circular letter to the members of standing committees is seen directly in the fact that during the month of May, 66 new members were elected, compared to 30 for May of 1919.

The Executive Committee desires to express its appreciation of the way in which the members have responded in "getting behind" the movement to increase the membership of the Society.

Standing Committees.—The activities of the standing committees during the past year have been most gratifying. A number of the committees whose work was most seriously curtailed during the war by the war activities of their members and also on account of unsettled industrial conditions, have resumed their work with increased energy; and it is apparent that the committees in general are now turning their attention more earnestly than ever to the many important problems confronting them. The volume and importance of the activities of the committees during the past year is evidenced from a summary given later in this report of the recommendations of the committees affecting standards and tentative standards.

The reorganization of Committee C-10 on Hollow Building Tile, referred to in the last annual report, has recently been effected. The Executive Committee looks forward confidently to renewed activity on the part of this important committee.

At the suggestion of the Executive Committee, Committee D-2 on Lubricants has considered its enlargement into a committee on Petroleum Products and Lubricants, covering such petroleum products as are not already under consideration by other committees. The Executive Committee expects to receive a final report upon this subject from Committee D-2 for consideration at its next quarterly meeting (June 23).

During the year considerable thought has been given to the reorganization of Committee E-1 on Methods of Testing in order to make it more thoroughly representative of the wide scope of the Society's activities in this important subject. A plan has finally been drafted, to which further detailed reference will be made later in this report.

At the request of Committee E-4 on Magnification Scales for Micrographs, the scope of the committee has been enlarged to a Committee on Metallography.

The organization of two new standing committees has been authorized during the year, namely, a committee on Screen Wire Cloth and a committee on Nomenclature and Definitions. It is expected to effect the formal organization of these committees soon after the annual meeting. Further reference is made later in this report to the conditions that led to the decision to organize the committee on Nomenclature and Definitions.

The Executive Committee now has under consideration the organization of a standing committee on Heavy Chemicals and a standing committee on Pyrometry, the latter having been suggested by Committee E-4 on Metallography.

Recommendations of Standing Committees Affecting Standards.—The recommendations of the standing committees affecting standards, contained in the reports as preprinted, subject to correction and modification, are presented below in summarized form for convenience in obtaining a general oversight of the work of these committees for the past year. These recommendations involve proposed revisions in 21 standards; 23 tentative standards recommended for adoption as standard; 28 proposed new standards; and proposed revisions in 13 tentative standards to be continued as tentative.

I. PROPOSED REVISIONS IN STANDARDS RECOMMENDED AS TENTATIVE.

Recommended by Committee A-1 on Steel:

For Quenched High-Carbon-Steel Splice Bars (A 49 – 15);
For Quenched Carbon-Steel Track Bolts (A 50 – 16);
For Quenched Alloy-Steel Track Bolts (A 51 – 16);
For Steel Screw Spikes (A 66 – 18);
For Structural Steel for Bridges (A 7 – 16);

For Structural Nickel Steel (A 8 – 16);
For Structural Steel for Buildings (A 9 – 16);
For Structural Steel for Locomotives (A 10 – 16);
For Structural Steel for Cars (A 11 – 16);
For Rivet Steel for Ships (A 13 – 14);
For Boiler Rivet Steel (A 31 – 14);
For Lap-Welded and Seamless Steel Boiler Tubes for Locomotives (A 28 – 18);
For Automobile Carbon and Alloy Steels (A 29 – 18).

Recommended by Committee A-2 on Wrought Iron:

For Welded Wrought-Iron Pipe (A 72 – 18);
For Staybolt Iron (A 39 – 18).

Recommended by Committee B-2 on Non-Ferrous Metals and Alloys:

For Copper Bars for Locomotive Staybolts (B 12 – 18).

Recommended by Committee C-1 on Cement:

Specifications and Tests for Portland Cement (C 9 – 17).[1]

Recommended by Committee C-6 on Drain Tile:

For Drain Tile (C 4 – 16).

Recommended by Committee D-1 on Preservative Coatings for Structural Materials:

For Purity of Raw Tung Oil (D 12 – 16).

Recommended by Committee D-3 on Methods of Sampling and Analysis of Coal:

Methods for Laboratory Sampling and Analysis of Coal (D 22 – 16).

Recommended by Committee D-6 on Coke:

Methods for Laboratory Sampling and Analysis of Coke (D 37 – 18).

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[1] Committee C-1 is recommending that the revision in these specifications be adopted as standard to become effective January 1, 1921.

II. TENTATIVE STANDARDS RECOMMENDED FOR ADOPTION AS STANDARD.

Recommended by Committee B-2 on Non-Ferrous Metals and Alloys:

Methods for Battery Assay of Copper (B 34 – 19 T).
Methods for Chemical Analysis of Pig Lead (B 35 – 19 T).

Recommended by Committee C-3 on Brick:

For Building Brick (C 21 – 19 T), as revised.

Recommended by Committee C-4 on Clay and Cement Sewer Pipe:

For Clay Sewer Pipe (C 13 – 18 T), as revised;
For Cement-Concrete Sewer Pipe (C 14 – 19 T), as revised.

Recommended by Committee C-8 on Refractories:

Test for Softening Point of Fire-Clay Brick (C 24 – 19 T);
Methods for Ultimate Chemical Analysis of Refractory Materials (C 18 – 18 T);
Test for Porosity and Permanent Volume Changes in Refractory Materials (C 20 – 18 T);
Test for Refractory Materials under Load at High Temperatures (C 16 – 18 T), as revised;
Definitions for Clay Refractories (C 27 – 19 T).

Recommended by Committee D-2 on Lubricants:

Test for Viscosity of Lubricants (D 47 – 19 T), as revised.[1]

Recommended by Committee D-4 on Road Materials:

Test for Loss on Heating of Oil and Asphaltic Compounds (D 6 – 19 T);[2]
Method for Determination of Softening Point of Tar Products (Cube-in-Water Method) (D 61 – 19 T);
For Materials for Cement Grout Filler for Brick and Stone Block Pavement (D 57 – 19 T);

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[1] When adopted as standard, this test will be added to the present Standard Tests for Lubricants (D 47 – 18).

[2] This test, when adopted, will supersede the present Standard Test for Loss on Heating of Oil and Asphaltic Compounds (D 6 – 16).

For Materials for Cement Mortar Bed for Brick, Stone Block and Wood Block Pavement (D 58 – 19 T).

Recommended by Committee D-7 on Timber:

For Southern Yellow-Pine Timber to be Creosoted (D 24 – 15 T);
For Southern Yellow-Pine Piles and Poles to be Creosoted (D 25 – 15 T);
For Wooden Paving Blocks for Exposed Pavements (D 52 – 18 T), as revised.

Recommended by Committee D-11 on Rubber Products:

For Leader Hose for Use with Pneumatic Tools (D 60 – 19 T);
For Steam Hose (D 54 – 18 T);
For Rubber Belting for Power Transmission (D 53 – 19 T).

Recommended by Committee D-13 on Textile Materials:

General Methods for Testing Cotton Fabrics (D 39 – 19 T).

Recommended by Committee E-4 on Magnification Scales for Micrographs:

Definitions and Rules Governing the Preparation of Micrographs of Metals and Alloys (E 2 – 19 T), as revised.

III. PROPOSED NEW TENTATIVE STANDARDS.

Recommended by Committee A-1 on Steel:

For Welded Steel Pipe;[1]
For Commercial Bar Steels.

Recommended by Committee A-2 on Wrought Iron:

Definitions of Terms Relating to Wrought-Iron Specifications.

Recommended by Committee B-2 on Non-Ferrous Metals and Alloys:

For Sheet High Brass;

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[1] Designed to replace, when adopted, the present Standard Specifications for Welded Steel Pipe (A 53 – 18).

For Aluminum for Use in the Manufacture of Iron and Steel;

Methods for Analysis of Spelter.[1]

Recommended by Committee C-8 on Refractories:

Method for Ultimate Chemical Analysis of Chrome Ores and Chrome Brick.[2]

Recommended by Committee C-9 on Concrete and Concrete Aggregates:

Methods for Making and Storing Specimens of Concrete in the Field;

Test for Unit Weight of Aggregate for Cement Concrete;

Method for Determination of Voids in Fine Aggregate for Cement Concrete.

Recommended by Committee C-11 on Gypsum:

For Gypsum Plasters.

Recommended by Committee D-1 on Preservative Coatings for Structural Materials:

For Turpentine.[3]

Recommended by Committee D-4 on Road Materials:

Test for Specific Gravity of Road Oils, Road Tars, Asphalt Cements and Soft Tar Pitches;

Test for Specific Gravity of Asphalts and Tar Pitches Sufficiently Solid to be Handled in Fragments;

Test for Quantity of Clay and Silt in Gravel for Highway Construction;

Test for Quantity of Clay in Sand-Clay, Topsoil and Semi-Gravel for Highway Construction;

Test for Quantity of Clay and Silt in Sand for Highway Construction;

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[1] These methods are to be prepared by publishing separately certain methods included in the Standard Specifications for Spelter (B 6 - 18); therefore this recommendation, if adopted, cannot be put into effect until 1921, when the next edition of the Book of Standards is printed.

[2] This method, when adopted as standard, will become a part of the Methods for the Ultimate Chemical Analysis of Refractory Materials (C 18 - 18 T) recommended for adoption as standard this year.

[3] Designed to replace, when adopted, the present Standard Specifications for Turpentine (D 13 - 15).

Methods for Sampling of Stone, Slag, Gravel, Sand and Stone Block for Use as Highway Materials, including Some Material Survey Methods;
For Proportions for Concrete for Highway Construction;[1]
For Workability of Concrete for Concrete Pavements;
For Commercial Sizes of Broken Stone and Broken Slag for Highway Construction;
For Commercial Sizes of Sand and Gravel for Highway Construction;
For Broken Slag for Waterbound Base;
For Shovel-Run or Crusher-Run Broken Slag for Waterbound Base;
For Natural or Artificial Sand-Clay Mixtures for Highway Surfacing.

Recommended by Committee D-10 on Shipping Containers:
General Specifications for Wooden Boxes, Nailed and Lock-Corner Construction.

Recommended by Committee D-11 on Rubber Products:
For Adhesive Insulating Tape.

Recommended by Committee D-13 on Textile Materials:
Methods for Testing Textiles.

IV. PROPOSED REVISIONS IN TENTATIVE STANDARDS TO BE CONTINUED AS TENTATIVE.

Recommended by Committee A-1 on Steel:
For Steel Tie Plates (A 67 – 18 T);
For Low-Carbon-Steel Track Bolts (A 76 – 18 T);
For Steel Plates for Forge Welding (A 78 – 19 T);
For Carbon Tool Steel (A 71 – 17 T);
For Electric Cast Steel Anchor Chain (A 77 – 18 T).

Recommended by Committee B-2 on Non-Ferrous Metals and Alloys:
For Lead (B 29 – 19 T);
For Aluminum Ingots for Remelting and for Rolling (B 24 – 19 T);

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[1] The recommendation for the publication as tentative of Specifications for Proportions for Concrete for Highway Construction, was withdrawn by Committee D-4 at the annual meeting (see Summary of the Proceedings, page 26). The material included under this title in the report as preprinted now appears as Appendix II to the report of Committee D-4, pages 437–440.—ED.

Methods for Chemical Analysis of Alloys of Lead, Tin, Antimony and Copper (B 18 – 17 T).

Recommended by Committee C-11 on Gypsum:

For Gypsum (C 22 – 19 T);

For Calcined Gypsum (C 23 – 19 T);

Methods for Tests of Gypsum and Gypsum Products (C 26 – 19 T).

Recommended by Committee D-7 on Timber:

For Selected Structural Douglas Fir Bridge and Trestle Timbers (D 23 – 16 T).[1]

Recommended by Committee D-10 on Shipping Containers:

For Canned Foods Boxes, Nailed and Lock-Corner Construction (D 44 – 17 T).[2]

Finances.—The annual statement of the finances of the Society follows in the form of the report of the auditors for the fiscal year January 1, 1919 to December 31, 1919. In connection with this statement, the Executive Committee desires to call special attention to the agreement that has been entered into with the Engineers' Club of Philadelphia by which the Society engaged to pay the cost of making alterations to the third floor of the building 1315 Spruce Street in order satisfactorily to house the offices of the Society, these payments to be accepted by the Club as advance payment of rent at the rate of $1000 per annum beginning January 1, 1920. It will be noted from the statement that during the past fiscal year $3600 has been so paid. This amount appears on the balance sheet as an asset, and together with subsequent payments on this account will be charged off as rent at the rate of $1000 per annum.

The surplus has been increased from $14,284.04 to $22,494.43. The increase in surplus for the year, $8,210.39, includes the above item of $3600 rent paid in advance, and $2000 invested towards a sinking fund to defray the cost of the 1921 Book of A.S.T.M. Standards.

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[1] These specifications have been entirely rewritten under the proposed new title "Tentative Specifications for Structural Douglas Fir."

[2] These specifications have been entirely rewritten under the proposed new title "Tentative Specifications for Wooden Boxes, Nailed and Lock-Corner Construction, for the Shipment of Canned Foods."

REPORT OF AUDITORS FOR THE FISCAL YEAR JANUARY 1, 1919, TO DECEMBER 31, 1919.

JOHN HEINS AND CO.
PUBLIC ACCOUNTANTS AND AUDITORS.

PHILADELPHIA, January 7, 1920.

AMERICAN SOCIETY FOR TESTING MATERIALS,
MR. C. L. WARWICK, *Secretary-Treasurer*,
Philadelphia, Pa.

Dear Sirs:

We respectfully report that we have made an audit and examination of the books and accounts of your Society for the six months ended December 31, 1919, having previously made a similar audit and report for the preceding six months ended June 30, 1919, and at both audits found the accounts to be correct and to be in their usual excellent condition.

We submit balance sheet as of December 31, 1919, as also a statement of cash receipts and disbursements for the twelve months then ended.

We have verified the transactions set forth in the budget record for the last six months, as also for the six months ended June 30, last, as reported in ours of July 16 and found the same to be correct.

Respectfully submitted,
(Signed) JOHN HEINS AND CO.

BALANCE SHEET AS OF DECEMBER 31, 1919.

ASSETS.			
Cash		$294.70	
Investments:			
$15,000 U. S. Liberty Bonds, 4th $4\frac{1}{4}$'s	$14,374.13		
1,300 U. S. Liberty Bonds, 4th $4\frac{1}{4}$'s, held for Life Membership Fund	1,227.45		
		15,601.58	
Accounts Receivable:			
For Publications	$2,034.90		
Members for binding	33.00		
Members for 1919 dues	1,347.50		
		3,415.40	
Rent paid in advance		3,600.00	
			$22,911.68
LIABILITIES.			
Accounts Payable		none	
Members' dues paid in advance		$412.25	
Members' binding paid in advance		5.00	
Life Membership	$1,300.00		
Surplus	21,194.43		
		22,494.43	
			$22,911.68

NOTE.—The stock of back publications and the office furniture are not appraised or included in this statement.

MISCELLANEOUS FUNDS.

In addition to the above cash the Secretary-Treasurer has on hand the following Funds:

Committee A-5 on Corrosion of Iron and Steel	$1,529.64	9	
Committee C-1 on Cement	2,059.47		
Committee C-9 on Concrete and Concrete Aggregates	621.24		
Committee C-10 on Hollow Building Tile	186.53		
			$4,396.88

EDGAR MARBURG MEMORIAL SCHOLARSHIP FUND.

Contributions by members of A. S. T. M	$4,528.74	
Contribution by A. S. T. M	438.36	
Interest on deposits	32.90	
Total—remitted to University of Pennsylvania July 22, 1919		$5,000.00

RECEIPTS AND DISBURSEMENTS.

JANUARY 1, 1919, TO DECEMBER 31, 1919.

Cash on hand, January 1, 1919			$7,164.93
RECEIPTS.			
Current dues	$34,417.27		
Past dues	452.43		
Advance dues	379.50		
		$35,249.20	
Sale of Publications:			
Separate Standards	$1,303.70		
Book of Standards	3,953.69		
Book of Tentative Standards	489.32		
Proceedings, etc	3,555.78		
		9,302.49	
Binding (Members)		639.00	
Sale of right to reprint Standards		925.00	
Authors' reprints		404.35	
Sale of Certificates of Membership		37.00	
Interest on deposits and investments		1,231.00	
Accrued interest		234.18	
Excess remittances		62.05	
Miscellaneous		11.00	
Total receipts			48,095.27
			$55,260.20

Brought forward	$55,260.20

DISBURSEMENTS.

Publications	$22,152.27	
Salaries	9,593.57	
Expenses, Secretary-Treasurer's office	2,362.10	
Expenses, Standing Committees	1,122.63	
Expenses, Nominating Committee	126.70	
Traveling expenses, Executive Committee	289.60	
Net expenses, Annual Meeting	998.93	
Rent and insurance, storage rooms	264.00	
Engrossing Certificates of Membership	26.25	
American Engineering Standards Committee	1,200.00	
Engineering Council	983.34	
Expenses, Representative on Engineering Council	27.15	
Advance rent, new headquarters	3,600.00	
New furnishings for headquarters	519.78	
Expenses of moving and temporary offices	149.63	
Edgar Marburg Scholarship	438.36	
Investments	10,778.35	
Accrued interest	234.18	
Contingencies	23.61	
Refund of excess remittances	64.05	
Miscellaneous	11.00	
Total disbursements		$54,965.50
Cash on hand December 31, 1919		$294.70

FINANCIAL CONDITION AT CLOSE OF FISCAL YEARS 1915–1919, INCLUSIVE.

Fiscal Year.	Assets.					Liabilities.	Deficit or Surplus.	
	Cash Balance.	Investment, Liberty Bonds.	Accounts Receivable.	Advance Rent.	Total.	Accounts Payable.	Deficit.	Surplus.[c]
1915	$103.54	......	$1 481.80	......	$1 585.34	$7 992.37	$6 407.03[a]	......
1916	845.78	......	2 595.24	......	3 441.02	300.93[b]	......	$3 140.09
1917	9 584.82	......	2 601.71	......	12 186.53	231.00[b]	......	11 955.53
1918	7 164.93	$4 880.63	2 569.95	......	14 615.51	331.47[b]	......	14 284.04
1919	294.70	15 601.58	3 415.40	$3 600.00	22 911.68	417.25[b]	......	22 494.43

[a] This deficit includes a reserve for uncollected membership dues of $813.

[b] These sums represent dues and binding paid in advance and do not include any unpaid bills.

[c] These items include $1300.00 on account of Life Memberships.

Receipts from Sales of Publications—The receipts from the sales of publications, $9302.49, are again the largest ever reported and exceed the returns from this source last year by $3163.49. The uniform increase in annual revenue from the sales of its publications is an excellent indication of the standing the Society has attained.

The increase in the sum realized from sales of publications over last year is due—aside from the normal annual increase in sales—to the large demand for the 1918 Book of A.S.T.M. Standards issued in November, 1918, and to the increase in the selling price of certain publications.

The receipts from the sales for one year of rights to reprint certain standards of the Society were as follows:

Carnegie Steel Company	$250.00
Illinois Steel Company	75.00
National Tube Company	100.00
Southern Pine Association	250.00
Steel Company of Canada	250.00
Total	$925.00

Inventory of Publications in Stock.—In the foregoing financial analysis no account has been taken of the assets of the Society in the form of publications in stock. The inventory of the Proceedings on May 15, 1920, is as follows:

VOLUME.	COPIES.	VOLUME.	COPIES.	VOLUME.	COPIES.
I	0	X	412	XVI, Part II	326
II	93	XI	371	XVII, Part I	194
III	0	XII	114	XVII, Part II	186
IV	114	XIII	433	XVIII, Part I	227
V	289	XIV, Part I	537	XVIII, Part II	218
VI	625	XIV, Part II	531	XIX, Part I	206
VII	349	XV, Part I	352	XIX, Part II	287
VIII	365	XV, Part II	314		
IX	495	XVI, Part I	327	Total	7365

The stock of publications in general on May 15, 1920, may be summarized as follows:

	NUMBER OF COPIES.
Proceedings	7365
1918 Book of A.S.T.M. Standards	150
Index (Vols. I–XII incl.)	717
Reports of Committee D-1 (1903–1914 incl.)	339

The sale of the 1918 Book of Standards so far exceeded the estimates made in 1918 that it has been necessary to print a second edition of 1000 copies for use until the 1921 volume is printed. The second edition is now on press.

Headquarters.—As forecast in the last annual report, an agreement was reached with the Engineers' Club of Philadelphia by which the headquarters of the Society have been established on the third floor of the Engineers' Club Building, 1315 Spruce Street, Philadelphia, Pa. Extensive alterations were made at a cost of $4467.17, which amount has been paid by the Society and will be credited as rent paid in advance at the rate of $1000 per annum.[1]

The Society's offices comprise about 1000 square feet of floor space. They include a committee room, general office room, the Secretary-Treasurer's office, and adequate storage space. The headquarters were occupied on January 5, 1920, and pending the completion of the alterations, which were somewhat delayed, the Engineers' Club courteously offered the Society the use without charge of two rooms as temporary headquarters from September 15 to January 5.

The offices have been furnished practically entirely new at a cost up to this time of $2434.79, of which amount $519.78 was paid during the past fiscal year.[2]

The members of the Society are expected to make use of the Society's headquarters in every way possible. The committee room is available without charge for meetings of the committees of the Society and their sub-committees. Arrangements have been made with the Engineers' Club by which committees that are too large to meet in the Society's room can hold their meetings in the Auditorium of the Club.

The growth of the Society that is reflected in the necessity for establishing headquarters has also made it necessary to increase the office personnel. Mr. J. K. Rittenhouse, whose connection with the Society dates from 1909, has been elected Assistant Treasurer, and a technical assistant to the Secretary-Treasurer has been engaged. The office personnel now numbers six.

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[1] Of the total amount, $3600 was paid in the last fiscal year. See report of auditors.

[2] See report of auditors.

A.S.T.M. COMMITTEE AFFAIRS.

During the past year a number of matters affecting the committee affairs of the Society have been under consideration by the Executive Committee, the importance of which warrants discussion at some length.

Shall Questions of Application, Workmanship and Recommended Practice be Included in Specifications for Materials?—At the last annual meeting of the Society, the Executive Committee was requested to decide the question of including in standard specifications for materials, requirements covering such matters as application, workmanship and recommended practice in general. This question had arisen during the discussion following the presentation by Committee C-11 on Gypsum of proposed Tentative Specifications for Gypsum Plaster which included requirements for the various types of plastered walls, and methods of application of plaster thereon.[1] In its consideration of this question the Executive Committee arranged for a conference with the officers of Committee C-11. Expressions of opinions were also invited from several members of the Society who had taken an active part in the discussion of the subject at the last annual meeting.

At this conference it was clearly developed that it is a function of the Society to establish specifications for the purchase and sale of materials; and that to include in such specifications provisions covering the use of the material and involving recommended practice for construction—such as in the present instance requirements for the erection of plaster, including studding, lath, background, etc.—would carry the Society beyond its well-defined and recognized field. Accordingly the Executive Committee adopted the following resolution at its meeting on January 22, 1920:

> "*First*, That the Executive Committee reaffirm the requirements in Section 14 of the Regulations Governing Standing Committees relating to 'Matters of Engineering Design,' as follows:
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> " 'In the preparation of proposed standards the consideration of matters of engineering design or construction shall not in general

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[1] See Summary of Proceedings of 1919 Annual Meeting, *Proceedings*, Am. Soc. Test. Mats., Vol. XIX, Part I, p. 29 (1919).

be regarded as falling within the province of the Society. If, however, it should appear to a given committee that the consideration of such matters is, for special reasons, indispensable in specifications designed to cover the customary relations between the producers and consumers of a given product, then reference to such matter in proposed specifications for that product shall be permitted within the scope necessary for the particular purpose above stated. Proposed standards embodying features of the character in question, shall be submitted by the committee concerned to the Executive Committee for consideration and comment not later than the quarterly meeting immediately preceding the annual meeting at which the proposed standards are to be presented.'

"*Second*, That it does not appear, with respect to the specifications for gypsum plasters in question, that the consideration of application, workmanship, erection or recommended practice in general is 'indispensable in specifications designed to cover the customary relations between the producers and consumers of a given product,' that product being in this instance gypsum plaster ready for application, and that therefore these considerations should not be included in the specifications for gypsum plasters.

"*Third*, That this interpretation of Section 14 of the Regulations shall be communicated to Committee C-11 and brought to the attention of the Society through the next annual report of the Executive Committee, to serve as a precedent in the consideration of similar problems in other committees."

Committee C-11 was advised of this ruling, and indicated to the Executive Committee its willing acquiescence; reserving, however, the privilege of reopening the question should the Society at any time widen the scope of its activities so that this question could be claimed to come within the extended field.

Resolution Adopted by Committee C-7 on Lime Recommending the Creation of a Standing Committee on Sand.—At the last annual meeting the following resolution, contained in the report of Committee C-7 on Lime, was referred to the Executive Committee:[1]

"That, whereas, sand is a material used broadly for construction purposes, and whereas, nearly all of the

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XIX, Part I, pp. 27 and 313 (1919).

> 'Group C' committees of the Society are interested in and have to deal with the question of sand as an admixture with the material over which each committee has jurisdiction, the Executive Committee be requested to instruct all standing committees interested in sand to elect sub-committees on this material; and that the Executive Committee be requested to create a standing committee on sand to be composed of one delegate from each of the above mentioned sub-committees."

In the consideration of this question the Executive Committee requested the advice of Committee E-5 on Standing Committees, since through its representative personnel that committee is well qualified to pass upon the desirability of creating a separate standing committee on sand, viewed from the question of Society policy.

The question at issue resolves itself into one of two proposals: One, the creation of a separate standing committee on sand as recommended, and the other, the formation of a conference committee consisting of representatives from the several standing committees concerned, similar to conference committees that have been formed in the past. A separate standing committee would have absolute jurisdiction over specifications for sand and would report direct to the Society, while a conference committee would serve principally as a means for enabling committees interested in specifications for sand to confer and reconcile differences, the conference committee reporting back to the committees represented on it.

In view of the nature of the problems involved in specifications for sand it was considered by Committee E-5 to be unwise to create a separate standing committee, and that committee adopted the following resolution, which was subsequently confirmed by the Executive Committee at its meeting on January 22, 1920:

> "That it is undesirable to create a separate standing committee on sand as suggested by Committee C-7, and that if any committees of the Society concerned with specifications for sand desire, the present machinery of the Society provides a satisfactory means of discussing matters

of common interest through the formation of a conference committee on which each standing committee concerned would be represented."

This ruling was communicated to Committee C-7 on Lime and in pursuance of its request the committee has been authorized to proceed with the formation of a conference committee on sand, to include representatives of the several other committees of the Society dealing with this subject.

Reorganization of Committee E-1 on Methods of Testing.—At the meeting of the Executive Committee held during the 1919 annual meeting, the following resolution was adopted:

> "*Whereas*, when Committee E-1 on Methods of Testing was first organized, iron and steel received the attention of the standing committees of the Society almost to the exclusion of other materials upon which physical tests are customarily made, and Committee E-1 has therefore devoted its time to problems connected with the testing of iron and steel; and
>
> "*Whereas*, the normal growth of the Society has been accompanied by a widening of the field of activities of its standing committees, including materials which have never been touched upon in this committee and upon which physical tests are made; and
>
> "*Whereas*, to keep pace with the expansion of the interests of the Society and to provide a committee to which may be referred questions pertaining to the methods of testing materials, the definition of terms used in recording results of tests and kindred problems, an increase in the membership of Committee E-1 appears necessary and a re-statement of the scope of the committee's activity seems desirable; therefore, be it
>
> "*Resolved*, that Committee E-1 be directed to prepare for the Executive Committee a report upon the best method, in their opinion, of increasing the membership of the committee and of broadening its activities so that it may cover the wide field of materials now under consideration by the standing committees of the Society and thereby put itself in position to become the general reference committee for all problems connected with methods of testing."

In pursuance of the directions contained in this resolution, Committee E-1 prepared a report, which was considered at the meeting of the Executive Committee in October, 1919. At this time it became evident that the reorganization of so important a committee as the one on Methods of Testing, involving as it does the activities of many other committees of the Society, could best be arrived at through a conference of members of

Committee E-1 and representatives of the standing committees. At the direction of the Executive Committee there were held two meetings of such a conference; and at the meeting of the Executive Committee on April 13, 1920, there was presented on behalf of this conference a plan of reorganization of Committee E-1, which is given in full in the excerpt from the minutes of that meeting appended to this report, in the form of "Proposed Regulations Governing Methods and Instruments of Testing." The principal features of the plan of reorganization, which has been approved by the Executive Committee, are as follows:

1. That the responsibility for the preparation of methods of testing and examination, design and recommendation of instruments for testing shall be vested in the standing committees.

2. That each standing committee shall designate one or more sub-committees to enable it properly to assume this responsibility.

3. That for administrative purposes there shall be established a reorganized Committee E-1 on Methods of Testing, which shall consist initially of seven members selected with special consideration of their interest, experience and ability in methods of testing, and with a view of making the committee as representative as possible of the broad activities of the Society. Each standing committee shall then elect not over two members who shall serve as Associate Members of Committee E-1 during the consideration by the committee of any matters relating to the standing committee they represent.

4. That the functions of Committee E-1 shall be, briefly, to aid the standing committees in the preparation of methods and instruments of testing, in the correlation of similar methods in different committees, and in instituting cooperation between the standing committees in matters relating to methods and instruments of testing; to initiate, conduct and report research upon such engineering constants, methods and instruments of testing as do not come under the functions of any other standing committee; to promote, with the approval of the Executive Committee,

cooperation in methods and instruments of testing with committees of other societies; to standardize nomenclature and definitions used in or relating to methods or instruments; and to perform such other functions as may advance the science of materials testing.

5. That the standing committees shall be required to cooperate with Committee E-1 in every way possible; to participate in the activities of the committee through their Associate Members, who shall have the full power, privileges and responsibilities of members of the committee during the discussion and final action upon recommendations in which the standing committee they represent are affected; and to refer to Committee E-1 for its consideration and advice any proposed method of testing or amendment thereof prior to their reference to the Society for adoption as standard.

The Executive Committee is now engaged in the selection of the personnel of the committee. In view of the fact that the work of the committee will be to quite a considerable extent administrative, involving the establishment of close cooperative relations with the various standing committees, it has been determined that the Secretary of the Society shall be, *ex-officio*, the secretary of the committee. It is hoped that sufficient progress can be made in this important matter to enable the reorganization of the committee to be effected soon after the annual meeting.

Reorganization of Committee E-6 on Papers and Publications.—The Executive Committee has approved the recommendation of Committee E-6 on Papers and Publications that it be reorganized after the annual meeting to provide for periodic change of personnel, which is considered desirable in so important an administrative committee, in the following manner:

That the Committee shall consist of nine members appointed by the Executive Committee and, *ex-officio*, the Secretary-Treasurer of the Society, who shall be chairman of the committee; and that the terms of office of the members shall be three years, so arranged that the terms of office of three members shall expire each year.

Creation of a New Standing Committee on Nomenclature and Definitions.—In October of 1919 a request was received from Committee C-11 on Gypsum "that the Executive Committee establish an official basis of cooperation on the subject of nomenclature between Committee C-11 and Committees C-1 on Cement, C-2 on Reinforced Concrete, C-4 on Sewer Pipe, C-5 on Fireproofing, C-6 on Drain Tile, C-7 on Lime, C-9 on Concrete and Concrete Aggregates, C-10 on Hollow Building Tile, D-1 on Preservative Coatings and D-4 on Road Materials, most of whom are concerned with the Tentative Definitions of Terms Relating to the Gypsum Industry (C 11 - 16 T) prepared by Committee C-11." In view of the nature of the question involved, this request was referred to Committee E-5 on Standing Committees, which recommended to the Executive Committee that a standing committee on Nomenclature and Definitions be created to consist of a representative from each committee of the Society, the Secretary-Treasurer of the Society to be *ex-officio* the secretary of the committee.[1] This recommendation was approved by the Executive Committee at its meeting on January 22, 1920, at which the creation of a standing committee on Nomenclature and Definitions was authorized with the following functions:

> "To receive the recommendations concerning nomenclature and definitions from the various committees of the Society and either to approve them or refer them back to the originating committee with such suggestions and modifications as seem necessary; to act as a correlating committee in all work on this subject and to furnish a means for committees working on allied subjects to work together on matters of definitions."

The Executive Committee has directed Committee E-5 to prepare regulations under which the proposed new committee shall function and it is expected that the committee will be formally organized shortly after the annual meeting.

Adoption of Standard Testing Sieves.—At the last annual meeting the Executive Committee was requested to consider a suggestion contained in the report of Committte C-7 on Lime relative to "the desirability of the adoption by the Society of the standard testing sieves promulgated by the Bureau of Standards."[1] At the meeting of the Executive Committee held October 14, 1919, the following resolution was passed:

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[1] Reference to this subject in more detail will be found in the annual report of Committee E-5 on Standing Committees.

> "That the Executive Committee approves in principle the use of a single series of standard testing sieves throughout the standards of the Society, and that the Secretary-Treasurer be directed to advise all standing committees involved of this fact, and to request their careful consideration of the adoption of the series of standard sieves promulgated by the Bureau of Standards."

In pursuance of this resolution a circular letter was sent to the following committees of the Society requesting consideration of the adoption of this series of standard sieves: Committees C-1 on Cement, C-2 on Reinforced Concrete, C-3 on Brick, C-4 on Sewer Pipe, C-6 on Drain Tile, C-7 on Lime, C-8 on Refractories, C-9 on Concrete and Concrete Aggregates, C-11 on Gypsum, D-3 on Methods of Sampling and Analysis of Coal, D-4 on Road Materials, D-5 on Coal and D-6 on Coke.

Expression of Measurements in A.S.T.M. Standards in Both English and Metric Units.—Mention was made in the last annual report of the Executive Committee that the American Engineering Standards Committee has recommended that units of measurements in American Standards be expressed in both English and metric units. This recommendation was referred to Committee E-5 on Standing Committees for its consideration and advice with respect to A.S.T.M. Standards. Committee E-5 recommended a revision in Section 19 on "Units of Measurements" of the Regulation Governing the Form but not the Substance of Standards.[2] This revision was distributed among the standing committees of the Society, and in pursuance of a request for reconsideration from Committee A-1 on Steel the Executive Committee has directed Committee E-5 to conduct a comprehensive hearing upon this subject, which all members of the standing committees who are interested will be invited to attend.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XIX, Part I, pp. 27 and 314 (1919).

[2] 1919 Membership List, p. 240.

Meetings of A.S.T.M. Committees.—The Executive Committee has approved the recommendation of Committee E-5 on Standing Committees to the effect

> "That the standing committees of the Society be requested to file with the Secretary-Treasurer a schedule of their regular meetings (and of sub-committee meetings), and to advise the Secretary-Treasurer in advance of calling a regular or special meeting in order that such meetings may, if possible, be scheduled at the Society's headquarters, or that advice may be given in the case of conflicts with other committees."

The preparation of a schedule of meetings is now being undertaken by the Secretary-Treasurer.

JOINT ACTIVITIES WITH OTHER ORGANIZATIONS.

The cooperation of the Society with other technical and scientific societies, discussed at some length in the last annual report of the Executive Committee, has been carried on vigorously during the past year and extended in some important directions. In fact, the discussion of matters of policy involved in some of the cooperative work of the Society has formed in some ways a major portion of the work of the Executive Committee during the year, and justifies, it is believed, the detailed statements which follow concerning these activities.

American Engineering Standards Committee.—It will be recalled that at the last annual meeting of the Society the Executive Committee reported that a proposed reorganization of the American Engineering Standards Committee was then under discussion, and that the following resolution adopted by the Executive Committee was announced at one of the sessions of that meeting:

> "*Resolved,* that it is the sense of the Executive Committee that the proposed change in the Constitution of the American Engineering Standards Committee is not looked upon with favor at this time, and that a committee be

appointed by the chair to confer with the other member bodies to get their views and report at the October meeting."

The original Constitution[1] of the Standards Committee provided that the membership should be limited to the five national engineering societies and three government departments originally represented, with no provision for expansion of membership. At conferences held with the other member bodies, the proposed changes were considered, and the decision was reached that the Constitution should be revised to provide for the admission of additional societies of national scope upon a three-fourths vote of the Standards Committee, provided that not more than one-fourth of the member bodies objected to such election within ninety days of notification thereof. Other revisions of secondary importance were necessitated by the expansion of the Committee. The revised Constitution (dated August 16, 1919) was approved by the governing boards of the societies and Government departments represented on the Standards Committee, including the Executive Committee. In view of the importance of the work of the Standards Committee, the revised Constitution is appended hereto.[2]

The Standards Committee also found it necessary, owing to the revisions of the Constitution, to amend the Rules of Procedure that had originally been ratified by the organizations represented on the Committee. The revised Rules of Procedure were carefully studied by the Executive Committee and approved, and they also are appended to this report in complete form.[2]

The Standards Committee has adopted By-laws for the conduct of its affairs, which have been submitted to the governing boards of the various member societies for approval. The Executive Committee has made certain suggestions of minor importance which are now under consideration by the Standards Committee. Since the By-laws involve only the management of the internal affairs of the Standards Committee, it has not seemed necessary to present them here.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XVIII, Part I, p. 46 (1918).

[2] The Constitution and Rules of Procedure of the American Engineering Standards Committee, here referred to, are not printed in this volume but appear on pages 265–273 of the 1920 Year Book.

Since the first of the year there have been elected to membership on the Standards Committee the following organizations:

- National Safety Council;
- Fire Protection Group (comprising National Fire Protection Association, National Board of Fire Underwriters and Associated Factory Mutual Fire Insurance Cos.);
- Electrical Manufacturers Council;
- National Electric Light Association; and
- Society of Automotive Engineers.

As stated in the last annual report, two standards of the Society, namely, the Standard Specifications and Tests for Portland Cement (C 9 – 17) and the Standard Specifications for Fire Tests of Materials of Construction (C 19 – 18), have been adopted as Tentative American Standard by the Standards Committee. The representatives of the Society on the Standards Committee have recently proposed the following five A.S.T.M. standards for consideration of the Standards Committee as American Standard:

- Standard Specifications for Drain Tile (C 4 – 16);
- Standard Tests for Toughness of Rock (D 3 – 18);
- Standard Tests for Penetration of Bituminous Materials (D 5 – 16);
- Standard Methods for Distillation of Bituminous Materials Suitable for Road Treatment (D 20 – 18); and
- Standard Methods for Sampling of Coal (D 21 – 16).

The Executive Committee has appointed a committee of three from its membership, who, together with the three representatives of the Society on the Standards Committee, have been charged with the selection of A.S.T.M. standards for submission to the Standards Committee for approval as American Standard. This committee now has under consideration a number of the specifications for ferrous and non-ferrous metals, and will in due course communicate with other committees of the Society concerning the submission of standards for other materials. Committees desiring to propose standards for submission to the Standards Committee are invited to communicate with the Secretary-Treasurer.

One of the important accomplishments of the Standards Committee that is of particular interest to the Society is the formation of a Sectional Committee on Standardization of Rolled Structural Steel Shapes, for which the Association of American Steel Manufacturers, American Society of Civil Engineers, American Railroad Association, and the Society of Naval Architects and Marine Engineers are acting as joint sponsors.

The representatives of the Society on the Standards Committee are President J. A. Capp, Past-President A. W. Gibbs, and Past-President A. A. Stevenson, who has been elected Chairman of the Committee.

Engineering Council.—The Society has continued its membership on Engineering Council, which dates from January 14, 1919, when the Executive Committee accepted election to membership on behalf of the Society. The representative of the Society on Engineering Council is Mr. Albert Ladd Colby.

Notwithstanding the fact that much of the work of Engineering Council recently has been somewhat outside of the immediate scope of the Society's activities, the Executive Committee has nevertheless followed the work of Engineering Council with much interest.

Under the auspices of Engineering Council there was held on January 23, 1920, a joint meeting of the governing boards of the five member societies of Engineering Council, at which there was had a full and comprehensive discussion of the future of Engineering Council, especially with reference to the recommendations contained in the report of the Joint Conference Committee of the four Founder Societies relative to the creation of a representative national engineering organization. One of the outcomes of this meeting was the adoption of the following resolution, which was subsequently confirmed by the governing boards of the four Founder Societies:

> "*Whereas*, this Conference of national engineering societies has considered the recommendations of the Joint Conference Committee of the four Founder Societies, therefore, be it
>
> "*Resolved*, that the Conference adopts in principle that report and requests the Joint Conference Committee

to call, without delay, a conference of representatives of national, local, state and regional engineering organizations to bring into existence the comprehensive organization proposed."

As an immediate result of this action there was held in Washington on June 3 and 4 a conference of representatives of national and local engineering organizations throughout the country for the purpose stated in the resolution. The Society was represented at this conference by three delegates, Vice-Presidents G. S. Webster and C. D. Young, and G. K. Burgess, and the report of the delegates will be considered by the Executive Committee at its next quarterly meeting (June 23).

At the conference meeting held on January 23 it developed that the present activities of Engineering Council would be seriously curtailed unless increased financial support were received from the member societies. The following resolution was accordingly passed:

> "*Resolved*, That the amount contributed for Engineering Council by each Founder Society shall be $5000 for the year 1920, in place of $3000, as now provided, and by American Society for Testing Materials, $1000 instead of $600."

This resolution was subsequently approved by the Executive Committee, making the Society's contribution to Engineering Council for this year $1000.

The consideration of several questions affecting the Society's relations with Engineering Council have been postponed pending the outcome of the conference of national and local organizations referred to above.

The American Railway Engineering Association has recently been elected a member of Engineering Council, making the sixth member.

Engineering Division, National Research Council.—It was announced in the last annual report that Past-President A. A. Stevenson had been appointed to represent the Society on the Engineering Division of the National Research Council, and the belief was expressed that in so far as the work of that Division relates to the work of engineering standardization, the Society can render an important service in the coordination of its activities with those of the Engineering Division.

During the year this expectation has been fully realized. The Engineering Division has created a research committee on the subject of High Speed Tool Steels, and arrangements have been made to coordinate their activities with those of the Sub-Committee on Specifications for Tool Steels, of Committee A-1 on Steel, by the appointment of the chairman of that subcommittee, Mr. J. M. Darke, as a representative of the Society on the committee of the Engineering Division. In a similar manner, a member of Committee D-4 on Road Materials will be appointed to serve as a representative of the Society on a committee of the Engineering Division on Road Construction and Highway Economics. In this way it will be possible to prevent duplication of effort in the two committees and to make available to Committee D-4 the results of the research and investigations planned by the Engineering Division's committee. Similar arrangements for the representation of the Society on a committee of the Engineering Division on Heat Treatment of Steel is now under consideration.

Conversely, the avoidance of duplication of effort in the study of magnetic analysis has been brought about by the appointment of a representative of the Engineering Division on our Committee A-8 on Magnetic Analysis. When the Engineering Division learned that this committee was effectively organized to study a problem that the Engineering Division have been requested to take up, it was entirely agreeable to them that the work should be carried on by our committee and arrangements have been made for their formal representation thereon.

Joint Committee on Investigation of Phosphorus and Sulfur in Steel.—At its meeting on October 14, 1919, the Executive Committee received a recommendation from Committee A-1 on Steel that it "invite the Bureau of Standards, the U. S. Railroad Administration, other consumers, and the Association of American Steel Manufacturers, to appoint representatives to serve with representatives of the Society on a proposed joint committee to investigate the effect of phosphorus and sulfur in steel, each group to appoint not more than two representatives," having in mind particularly the question of whether the phosphorus and sulfur limits in the A.S.T.M. steel specifications are proper ones. This recommendation was favorably considered by the Executive Committee, and under its direction there was organized, on November 29, 1919, a Joint Committee on Investigation of Phosphorus and Sulfur in Steel, under the chairmanship of G. K. Burgess of the Bureau of Standards, consisting of representatives from the following nine organizations: U. S. Bureau of Standards, U. S. Railroad Administration, American Society for Testing Materials, Association of American Steel Manufacturers, U. S. War Department, U. S. Navy Department, U. S. Shipping Board, Society of Automotive Engineers, and Steel Founders' Society of America. Since the formal organization of the committee, the membership of the U. S. Railroad Administration has been taken over by the American Railroad Association; that of the U. S. Shipping Board by the Society of Naval Architects and Marine Engineers; and the Engineering Division of the National Research Council has been added. The secretary of the joint committee is the Secretary-Treasurer of the Society.

Information in considerable detail with respect to the activities of the joint committee will be found in the annual report of Committee A-1 on Steel.

Organization of Joint Committee on Standard Specifications for Concrete and Reinforced Concrete.—In the last annual report announcement was made of the decision of the Executive Committee to invite the American Society of Civil Engineers, American Railway Engineering Association, American Concrete Institute and the Portland Cement Association to cooperate with this Society in the preparation of standard specifications for concrete and reinforced concrete. Acceptances from each of these organizations having been received, the Executive Committee prepared, after conference with the chairman and secretary of Committee C-2 on Reinforced Concrete, an outline of organization of the proposed joint committee, which was submitted to each of the proposed cooperating bodies for their approval. (This outline of organization appears in full in the excerpt from the minutes of the meeting of the Executive Committee October 14, 1919, appended to this report.)

The outline of organization was approved substantially without criticism by the various cooperating bodies, and the organizations appointed the five representatives agreed upon.

The Executive Committee appointed the following as representative of the Society: Messrs. Richard L. Humphrey, chairman, A. T. Goldbeck, E. E. Hughes, L. S. Moisseiff and H. H. Quimby. A meeting for organization was held in Philadelphia on February 11, 1920, at the invitation of the Executive Committee; Vice-President G. S. Webster acting as temporary chairman and the Secretary-Treasurer as temporary secretary of the meeting until the premanent organization of the joint committee was effected. By-laws were adopted embodying in every detail the outline of organization approved by the five cooperating bodies, as well as provisions for conduct of the work of the joint committee. Mr. Richard L. Humphrey, representing this Society, was elected chairman, Mr. J. J. Yates, representing the American Railway Engineering Association, was elected vice-chairman, and Mr. D. A. Abrams, representing the Portland Cement Association, was elected secretary-treasurer of the joint committee. Further details of the organization of the joint committee, including the appointment of sub-committees on various aspects of this work, will be found in the annual report of Committee C-2 on Reinforced Concrete.

Cooperation with Mechanical Section, American Railroad Association.—At its meeting held during the last annual meeting, the Executive Committee decided that the importance of uniform standards for railroad materials was so great as to warrant a proposal to the Mechanical Section of the American Railroad Association and to the U. S. Railroad Administration, that if possible some basis of cooperation between those two bodies and the Society be established in the preparation of standards for such materials. The executive bodies of the other two organizations were receptive to this suggestion and after two conferences an outline of method of cooperation was approved by the respective governing boards as a desirable method of procedure in the joint consideration of standards for railroad materials, with the understanding that it is to be subject to change in the light of developments as the cooperative work proceeds. This outline is given in full in the excerpt from the minutes of the Executive Committee meeting on January 22, 1920, appended to this report. Briefly, the plan calls for the organization of joint committees consisting of representatives from each cooperating body, such that the joint committee will be fairly representative of all interests concerned in the preparation of the standards in question. These joint committees will elect their own officers and will proceed as independent committees in the consideration of the standards with whose preparation they have been charged. The reports of these joint committees will be submitted to the proper authorities in each cooperating body, with the understanding that each such body reserves the right of independent action. It is understood, however, that the joint committees will be given an opportunity of considering any revisions in their reports suggested by the cooperating bodies before those bodies take final action. So far as our Society is concerned, the A.S.T.M. representatives on a joint committee become in effect a sub-committee of one of the standing committees of the Society (or in some instances perhaps a standing committee itself). The report of each joint committee will be considered by the appropriate standing committee and acted upon entirely independently in accordance with the regulations of the Society. If the standing committee desires to revise the report of a joint committee, such revisions will first be referred to the joint committee for its consideration before the standing committee ultimately submits its recommendations to the Society.

It is believed that under this plan of cooperation it will be possible gradually to arrive at uniform standards for railroad materials, which will be of incalculable benefit to the railroads and to the industries that supply railroad materials.

One joint committee has been organized under this plan of cooperation, namely, a Joint Committee on Steel Castings for Railroads. The Executive Committee has appointed fifteen members to represent the Society on this joint committee, all of whom are members of Committee A-1 on Steel, and thereby become in effect a sub-committee on railroad castings of that committee. Further reference to the activities of this joint committee will be found in the annual report of Committee A-1 on Steel.

The formation of other joint committees is under consideration.

Cooperation with American Railway Engineering Association.—Reference was made in the last annual report of the Executive Committee concerning cooperative work with the American Railway Engineering Association in the consideration of specifications for various track accessories. Such cooperative work that has been done in this direction during the past year has been profitable, it is believed, to both organizations. Mention of this subject will be found in the annual report of Committee A-1 on Steel.

The Executive Committee was unable to bring about the formal cooperative relations that it was hoped to establish between Committee A-1 on Steel and the Rail Committee of the American Railway Engineering Association, for the purpose of joint consideration of specifications for steel rails. The Executive Committee understands that Committee A-1 will proceed independently with the consideration of revisions in the Society's Specifications for Carbon-Steel Rails, and that the committee will make every endeavor to meet the recommendations of the A. R. E. A. Rail Committee.

Cooperation with A. S. M. E. Boiler Code Committee.—The Executive Committee has continued the plan of maintaining a special committee for the purpose of cooperating with the Boiler Code Committee of the American Society of Mechanical Engineers, as first announced in its annual report in 1917. The present personnel of the committee is Mr. F. J. Cole, Mr. C. F. W. Rys, and the Secretary-Treasurer. The committee is authorized to confer with the representatives of the Boiler Code Committee on any questions affecting the Boiler Code in which the two societies are mutually interested.

Standardization of Aircraft Materials.—In the last annual report of the Executive Committee, the statement was made that Committee A-1 on Steel has had under consideration the question of standardization of specifications for aircraft steels; and that in view of the desirability of working in cooperation with the Society of Automotive Engineers, the Executive Committee invited that Society to consider the formation of a joint committee on this subject. During the year the Society of Automotive Engineers has been elected to membership in the American Engineering Standards Committee, so that the way is now open for standardization of aircraft steels and other materials through the formation of sectional committees in accordance with the procedure of the Standards Committee, upon which sectional committees the Society will have due representation. The Executive Committee understands that the question of aircraft standardization has been under consideration by the Standards Committee during the past several months, but that the time has not yet arrived to undertake an extensive program of standardization in this important new field.

Conference with Government on the Question of Fineness in Specifications for Cement.—At the request of Committee C-1 on Cement, the Executive Committee arranged for a conference of representatives of the Society with the U. S. Government Departmental Committee, for the purpose of reaching, if possible, an agreement between the Society's requirements for fineness of cement and those announced by the Government to become effective January 1, 1921, and to give Committee C-1 an opportunity of presenting to the Government Departmental Committee certain important data on the subject of fineness of cement that the committee had accumulated since the Society's specifications were adopted in their present form. This conference was held in Washington on May 10, at which the Society was represented by Messrs. Ernest Ashton, R. S. Greenman, Richard L. Humphrey, F. W. Kelley, H. B. MacFarland, and the Secretary-Treasurer. The conference resulted in an agreement which, if endorsed in due course by the Society and the appropriate authorities of the Government, will permit of single uniform Standard Specifications and Tests for Portland Cement throughout the country. Further reference in detail to this subject will be found in the annual report of Committee C-1 on Cement.

Other Cooperative Work.—It is desired to make brief mention of certain other cooperative work in which the Society is represented:

The Society is represented on a Joint Committee on Concrete Culvert Pipe by Mr. H. T. Shelley and Mr. A. E. Phillips. Announcement of Mr. Shelley's appointment was made in the last report of the Executive Committee and since that time Mr. Phillips has been appointed as a second representative. This joint committee consists of two representatives from each of the following organizations: American Concrete Institute, American Association of State Highway Officials, American Railway Engineering Association, American Society for Testing Materials, American Concrete Pipe Association, American Society of Civil Engineers, and the U. S. Bureau of Public Roads.

Reference was made in the last annual report of the prospective formation of a Joint Committee on Standard Pattern Practice. Such a joint committee has been organized during the past year under the sponsorship of the American Foundrymen's Association and consists of two representatives from each of the following organizations: American Foundrymen's Association, National Association of Pattern Makers, Steel Founders' Society of America, American Malleable Castings Society, Metals Division of the American Institute of Mining and Metallurgical Engineers, and the American Society for Testing Materials. The representatives of the Society on this joint committee are Mr. J. C. Davis of the American Steel Foundries and Mr. George Correy of the Worthington Pump and Machinery Co.

The Society has continued its representation on the American Bureau of Welding, referred to in the last annual report of the Executive Committee. The representative of the Society on this Bureau is Mr. F. M. Farmer.

The Society is represented on the Conference for Standardization of Technical Symbols by the Secretary-Treasurer.

During the past year the Society has been officially represented at the following three meetings: (1) At the Industrial Safety Conference held at the Bureau of Standards, Washington, D. C., December 8, 1919, by Vice-President C. D. Young; (2) at the Second National Public Works Department Convention held in Washington, D. C., January 13–14, 1920, by Mr. S. S. Voorhees; and (3) at the Annual Meeting of the National Federation of Construction Industries, Chicago, Ill., March 24–25, 1920, by the Secretary-Treasurer. Upon the invitation of the Federation, the Secretary-Treasurer presented an address on the subject "Standardization and the American Society for Testing Materials."

Translation of A.S.T.M. Standards into French.—The Executive Committee is able to report progress in the translation of certain specifications of the Society into French under the agreement between the U. S. Department of Commerce and the Society, which has been referred to in previous annual reports of the Executive Committee. It is hoped that the English-French edition of those specifications having an important bearing on the requirements of export trade will be published during the next year.

Edgar Marburg Memorial Scholarship.—The Executive Committee takes pleasure in advising the members that the Edgar Marburg Memorial Scholarship was formally presented to the University of Pennsylvania and accepted by the University on July 23, 1919. The members will recall that this gift is in the form of an endowment of $5000, the interest of which maintains a scholarship that is to be held by a student in the Department of Civil Engineering of the University, of which Doctor Marburg was Professor-in-charge from 1892 until his death in 1918. The present holder of the scholarship is Harry R. Halloran of Philadelphia, who has made an excellent record in his first year's work.

1920 Annual Meeting.—The decision of the Executive Committee to hold the annual meeting this year at Asbury Park, N. J., thus departing from a precedent of fifteen years of meeting in Atlantic City, was arrived at only after a careful and earnest consideration of the circumstances. It developed that it would be impracticable to arrange for the annual meeting this year to be held at Atlantic City during the week desired. Moreover, the special rates that were granted to members of the Society attending the meetings could not be obtained this year, and for this and other reasons the Executive Committee felt it necessary to make other arrangements for the meeting. The selection of a place of meeting was then placed in the hands of a special committee, which after a thorough canvass recommended Asbury Park. It is believed that excellent facilities for the meeting, including arrangements for committee meetings and for entertainment of the members and their guests, have been provided, and the Executive Committee looks forward with confidence to one of the most successful meetings in every way that the Society has ever held.

Respectfully submitted on behalf of the Executive Committee,

J. A. CAPP,
President.

C. L. WARWICK,
Secretary-Treasurer.

APPENDIX.

EXCERPTS FROM MINUTES OF THE EXECUTIVE COMMITTEE.

Regular Meeting, June 25, 1919.—Hotel Traymore, Atlantic City, N. J. Present: President, G. H. Clamer; Vice-President, Geo. S. Webster; Past-President, A. A. Stevenson; Members of Executive Committee, G. Aertsen, G. K. Burgess, J. A. Capp, G. B. Heckel, W. M. Kinney, C. D. Young; Members-elect of Executive Committee, Ernest Ashton, H. F. Moore, C. F. W. Rys, and Capt. W. J. Baxter representing Admiral D. W. Taylor; and Secretary-Treasurer, C. L. Warwick.

The Secretary-Treasurer called attention to the fact that the action taken at the last regular quarterly meeting relative to the proposed election to honorary membership of Dr. H. M. Howe, Capt. Robert W. Hunt, and Prof. Mansfield Merriman, had purposely been omitted from the minutes distributed to the members of the committee in order that Prof. Merriman might not be apprised in advance of the annual meeting of this action, which it was agreed should be announced at the Tuesday Evening session of the annual meeting. The Secretary-Treasurer then read the minute in question:

> Past-President Stevenson presented the following communication under date of March 17, directed to the Executive Committee:
>
> "We, the undersigned members of the American Society for Testing Materials, respectfully nominate Professor Mansfield Merriman, Doctor Henry M. Howe and Captain Robert W. Hunt as Honorary Members of the American Society for Testing Materials. We feel that these men, by virtue of their standing, their work for the A.S.T.M. during a period of many years, and the fact that they are Past-Presidents of the Society, warrant this recommendation."
>
> (This petition bears the signatures of eleven members of the Society.)
>
> The President announced that he had communicated with every member of the Executive Committee—with the exception of Past-President Merriman—on the above proposal and he received a favorable response from each member.
>
> Past-President Stevenson moved the election of Capt. Robert W. Hunt, Dr. Henry M. Howe, and Prof. Mansfield Merriman, all Past-Presidents of the Society, to Honorary membership in the Society, which was unanimously carried.
>
> *Voted*, that the correspondence in this matter conducted by President Clamer be constituted a legal letter ballot.
>
> It was agreed that the announcement of these elections be made at the memorial session at the annual meeting."

The President-elect, Mr. J. A. Capp, announced the appointment of the following Finance Committee: Mr. G. Aertsen, Chairman, Mr. G. K. Burgess and Mr. C. F. W. Rys.

The Secretary-Treasurer reported that favorable action had been taken on 137 new applications for membership, 4 members had resigned and that the Society had suffered the loss by death of 4 members, making the total membership in the Society on June 25, 1919, 2481.

The Secretary-Treasurer presented a financial statement for the quarter which was accepted and ordered spread upon the minutes.

The Chairman of the Finance Committee presented a report on the proposed removal of the headquarters of the Society to down-town Philadelphia. He reported that the Finance Committee had investigated locations in office buildings and in the Engineers' Club. The possibilities of making satisfactory arrangements with the Engineers' Club seemed very favorable and the Committee took preliminary steps looking towards the establishment of headquarters at the Club, using a portion of the third floor of the building recently acquired and in part now used by the Club, 1315 Spruce Street.

Voted, that the Finance Committee in connection with the officers of the Society be given authority to proceed in this matter as seemed to them best.

Voted, that the Secretary-Treasurer be authorized to prepare a suitable resolution to be sent to the University of Pennsylvania, expressing appreciation for the many courtesies and privileges extended to the Society during its long sojourn at the University and that this resolution be sent at a time to be designated by the Committee in charge of establishing headquarters.

The question of the desirability of holding a "Committee Week" for meetings of standing committees was discussed. It was agreed that the matter of arranging for the concentration of committee meetings at a given period, be referred to Committee E-5 on Standing Committees.

The Secretary-Treasurer read a letter under date of June 3, from Provost Smith of the University of Pennsylvania, accepting on behalf of the University the establishment by the Society of the Edgar Marburg Memorial Scholarship in the Department of Civil Engineering at the University of Pennsylvania. The Secretary-Treasurer was directed to follow the progress of the student to whom this scholarship is awarded and to report in the matter to the Executive Committee annually.

The Secretary-Treasurer announced that in pursuance of authority granted by the Executive Committee on January 16, 1917, Committee C-1 on Cement is now proceeding with the publication of a special volume, devoted to the reports of the Joint Conference on Cement and the investigations of the subcommittees of Committee C-1; and that proof of this matter will be submitted to the Secretary-Treasurer before the volume goes to press.

In the matter of the proposed formation of a joint committee on Specifications for Reinforced Concrete, the Secretary-Treasurer reported that three of the four societies invited to cooperate with the A.S.T.M., had advised that the matter would be referred to their governing boards at the first opportunity.

Voted, that a special committee of three be appointed to confer with Committee C-2 and the four proposed cooperating societies, and to arrange all details in connection with the formation of the Joint Committee, with the understanding that a report will be presented at the October meeting of the Executive Committee.

A communication under date of May 21 was presented from Mr. Henry

M. Howe, reporting on the progress of his conference abroad in the matter of organizing an International Society for Engineering Materials, which was accompanied by the following resolution:

> "Resolutions adopted at an informal Conference with Mr. H. M. Howe, Chairman of the Engineering Division of the American National Research Council at Washington, and a Past-President of the now defunct International Association for Testing Materials, held at the Institution of Civil Engineers, Great George Street, Westminster, London, S. W. I., on Thursday, May 15, 1919.
>
> "(1) That this informal Conference favors a careful inquiry as to the expediency of forming an International Association to take up the investigation and standardization of the methods of testing engineering and other important materials.
>
> "(2) That this informal Conference requests its Chairman—
>
> "(*a*) To inform the leading technical Societies, interested in the matters under discussion, of the resolutions passed by this informal Conference.
>
> "(*b*) To invite these Societies to nominate representatives to attend a larger Conference.
>
> "(*c*) To invite the attendance of further representative persons whose advice he may consider would be advantageous to such Conference."

The following resolution was introduced and on motion adopted:

> *Resolved*, That Committee E-1 be directed to prepare for the Executive Committee a report upon the best method, in their opinion, of increasing the membership of the Committee and of broadening its activities so that it may cover the wide field of materials now under consideration by the standing committees of the Society and thereby put itself in position to become the general reference committee for all problems connected with methods of testing.

A letter under date of June 25, from Mr. C. M. Chapman was presented, requesting that the title of the Standard Test for Flash Point of Volatile Paint Thinners, presented by Committee D-1, be changed to Standard Test for Flash Point of Volatile Inflammable Liquids, for the reason that the test was used in connection with oils not used for paint thinners, such as illuminating oil, signal oil, solvents, etc.

It was agreed that this matter should be referred to Committees D-1 and D-2 with the suggestion that they unite in making a suitable recommendation in this matter.

The proposed reorganization of the American Engineering Standards Committee was then considered.

After a lengthy discussion of this subject, the following motion was adopted, with the understanding that announcement of this action would be made at the Thursday Morning Session of the annual meeting:

Voted, that it is the sense of the Executive Committee that the proposed change in the Constitution of the American Engineering Standards Committee is not looked upon with favor at this time, and that a committee be appointed by the chair to confer with the other member bodies to get their views and report at the October meeting.

A letter was presented under date of June 23, from Mr. Charles A. Lunn, recommending the appointment of a committee to formulate specifications for absorbent (wash) oil used in the washing of coke-oven or city gas supplies for recovery of light oil containing benzol, toluol and xylol as main constituents.

The Secretary-Treasurer was instructed to secure further information as to the desirability of the creation of such a committee, and it was agreed that if the creation, of a committee on this subject should be found very desirable, the President and Secretary-Treasurer should be authorized to proceed in the usual manner.

President Clamer suggested the desirability of creating a committee on specifications for heavy chemicals. The Secretary-Treasurer referred to correspondence be had had with Mr. W. H. Bassett and the American Wire Fabrics Company in connection with the proposed creation of a committee on specifications for wire cloth and weaving wire.

The Secretary-Treasurer was instructed to secure further data on the desirability of creating these two committees, for presentation at the next quarterly meeting.

Past-President Stevenson called attention to the desirability of cooperation between the Society and the Mechanical Section of the American Railroad Association. It was decided to ask the Executive Committee of the Mechanical Section, A. R. A. to appoint a committee to confer with a committee to be appointed by the President with a view of realizing the desired end.

REGULAR MEETING, October 14, 1919.—Afternoon Session, Engineers' Club, Philadelphia; Evening Session, Union League, Philadelphia. Present: President, J. A. Capp; Vice-Presidents, Geo. S. Webster, C. D. Young; Past-Presidents, A. A. Stevenson, W. H. Bixby, G. H. Clamer; Members of Executive Committee, G. Aertsen, G. K. Burgess, G. B. Heckel, H. F. Moore, C. F. W. Rys, R. P. Hodgson, representing Admiral D. W. Taylor (present for about an hour, arriving at 3.30); Secretary-Treasurer, C. L. Warwick. Past-President A. W. Gibbs was present by invitation during the consideration of the proposed reorganizations of the American Engineering Standards Committee.

The Secretary-Treasurer reported that favorable action had been taken on 88 new applications for membership, that one member had resigned and that the Society had suffered the loss through death of 2 members, making the total membership in the Society on September 30, 1919, 2566.

The Secretary-Treasurer presented a financial statement for the quarter which was accepted and ordered spread upon the minutes.

The semi-annual report of the auditors was presented and ordered spread upon the minutes.

On the recommendation of the Secretary-Treasurer, Mr. J. K. Rittenhouse was elected Assistant Treasurer of the Society.

The Secretary-Treasurer read a letter which he had directed to the Provost of the University of Pennsylvania under date of October 8, in pursuance of the action taken by the Executive Committee at its last meeting, expressing the appreciation of the Executive Committee of the many courtesies and privileges enjoyed by the Society during the many years that it maintained its headquarters in the Department of Civil Engineering.

The Secretary-Treasurer read a letter under date of July 23 from the Provost of the University of Pennsylvania acknowledging receipt of $5000.00 for the endowment of the Edgar Marburg Memorial Scholarship in the Civil Engineering Department of the University of Pennsylvania, expressing his appreciation on behalf of the Corporation of the University and himself to the Society for this generous gift.

The report of the tellers, Mr. H. T. Shelley and Mr. W. A. Slater, on the result of the letter ballot on (*a*) the amendment of the by-laws, and (*b*) the adoption as standard of ten tentative standards as announced in Circular to Members No. 149, issued on September 13, was presented as follows and formally accepted:

	Aye	Nay	Not Voting
Proposed Amendments of the By-Laws:			
Article I, Section 3	305	8	66
Article II, Section 5	311	3	67
TENTATIVE STANDARDS TO BE ADOPTED AS STANDARD.			
Specifications for:			
1. Malleable Castings (A 75 – 18 T)	128	3	240
2. Cartridge Brass (B 19 – 18 T)	67	3	296
3. Cartridge Brass Disks (B 20 – 18 T)	66	3	297
4. Naval Brass Rods for Structural Purposes (B 21 – 18 T)	74	0	290
Tests for:			
5. Flash Point of Volatile Paint Thinners (D 28 – 18 T)	111	2	252
6. Determination of Apparent Specific Gravity of Sand, Stone and Slag Screenings and Other Fine Non-Bituminous Highway Materials (D 55 – 18 T)	100	3	260
Methods for:			
7. Chemical Analysis of Manganese Bronze (B 27 – 18 T)	99	1	265
8. Chemical Analysis of Gun Metal (B 28 – 18 T)	96	1	268
9. Determination of Softening Point of Bituminous Materials other than Tar Products (D 36 – 16 T)	97	5	263
Recommended Practice for:			
10. Laying Sewer Pipe (C 12 – 17 T)	82	3	280

Total number of legal ballots cast.......................... 407

The Secretary-Treasurer presented a request from Mr. J. A. Newlin, Chairman of Committee D-10 on Shipping Containers, that the Committee be permitted to consider the adoption of specifications for shipping containers prepared by other organizations, the request setting forth that the committee, on account of its balanced personnel, was in a most advantageous position to act as a clearing house for the consideration of various specifications for containers. The Secretary-Treasurer further reported that he had had a conference concerning this matter with Colonel B. W. Dunn, who was the chairman of the committee at the time of its organization, and that Colonel Dunn was very clearly of the opinion that the work of Committee D-10 in preparing specifications for containers would be seriously hindered unless it could take up for consideration the specifications prepared outside of the committee itself. It was explained that there is no other technical Society engaged in this field and that the outside specifications are, generally speaking, those prepared by the Bureau of Explosives for the Interstate Commerce Commission, by other Government Departments, and by organizations of manufacturers.

It was the expressed sense of the Executive Committee that the request of Committee D-10 should be granted, and that the Secretary-Treasurer should explain to the committee the practice of certain other committees in the Society of tabulating the requirements of existing specifications as one of the first steps in the preparation of a specification to be presented ultimately to the Society.

The Secretary-Treasurer presented the following resolution which had been adopted by Committees D-4 on Road Materials and D-8 on Waterproofing:

> "Moved that it is the sense of Committee D-4 (D-8) that while it recognizes the great advantages to be derived from cooperation with committees of other societies, it is opposed to establishing the practice of holding joint sessions with associations devoted to special interests as it believes that the pursuit of such a policy will result in the lowering of the standing of the Society.
>
> Committee D-4 (D-8), therefore, calling attention to the proposed joint session with the American Concrete Institute on Friday, June 27th, respectfully protests to the Executive Committee against the establishment of this practice.
>
> It is further moved that a copy of this motion be forwarded to the Executive Committee by the Secretary."

The special committee appointed by the President to consider this resolution presented a report, to the effect that after a very careful and comprehensive consideration of the resolution it felt that it was undesirable to make a general recommendation to the Executive Committee against the holding of joint sessions with other societies; and recommended that any suggestions for joint meetings which may hereafter be received should be considered by the Executive Committee strictly on their merits.

On motion this report was adopted and the Secretary-Treasurer directed to advise Committees D-4 and D-8 of the action taken.

The Secretary-Treasurer presented the following resolution adopted by Committees D-4 on Road Materials and D-8 on Waterproofing:

> "*Whereas,* The expense and labor involved in the preparation of duplicate committee reports is so great as to constitute a serious burden on the officers and members of committees; and

"*Whereas*, No provision has been made by this Society to cover this expense,

"*Resolved*, That Committee D-4 (D-8) believes that the Society should create a bureau for the prompt and efficient preparation of duplicate reports for committees without expense to them, and that this bureau should also mail these reports to the members of the various committees interested."

It was the sense of the Executive Committee that it is inadvisable at this time to establish such a bureau. Attention was called to the fact that the Regulations Governing Standing Committees provide for the assumption by the Society of certain committee expenses, and the Secretary-Treasurer was directed to bring this to the attention of Committees D-4 and D-8, and to explain how other committees in the Society take advantage of it.

The Secretary-Treasurer presented a suggestion from Committee D-4 on Road Materials "that in the future all entertainment features in connection with annual meetings of the Society be placed either at the beginning or the end of the program in order not to interfere with business of the Society."

On motion, this suggestion was referred to Committee E-6 on Papers and Publications for such action as may seem best in making up the annual program.

The report of the committee appointed to study the proposed reorganization of the American Engineering Standards Committee and to confer with the other member bodies on that Committee, was presented.

After considerable discussion this report was accepted and it was:

Voted, that the Executive Committee of the American Society for Testing Materials approves the proposed revised Constitution of the American Engineering Standards Committee dated August 16, 1919; with the understanding that the "rules under which committees to create standards shall be constituted and organized," provided for in Section 24 of the Constitution, shall conform in principle to the present Rules of Procedure; and with the further understanding that By-laws which may be adopted by the Standards Committee under the provision in Section 32 of the Constitution, together with any modifications of the present Rules of Procedure, shall be subject to approval by this Society.

It was expressed as the sense of the Executive Committee that the requirement in this motion by which By-laws and modifications of existing Rules of Procedure should be subject to approval of the Society, is not intended to operate to delay the conduct of business of the Standards Committee under such By-laws and modified Rules of Procedure as may be adopted by the Committee, pending their approval by the Society.

On motion, Mr. A. A. Stevenson was re-elected as the representative of the Society on the American Engineering Standards Committee for a term of three years.

The Secretary-Treasurer stated that he had corresponded with the officers of Committee D-2 on Lubricants concerning the proposal of Mr. Charles A. Lunn, presented at the last meeting of the Executive Committee, that a committee be created to prepare specifications for absorbent oil; and that in his opinion the proposal of Mr. Lunn could best be met by enlarging the present Committee on Lubricants to include other petroleum products, including absorbent oil; and that moreover the attitude of the officers of Committee D-2 appeared to be favorable to such an enlargement. It was accordingly voted that the title of Committee D-2 be changed to Committee D-2 on Lubricants and Petroleum Products, with the consent of the committee, and that the necessary steps be taken for the enlargement of the committee indicated by the proposed title.

The Secretary-Treasurer reported that he had referred to the officers of Committees D-1 and D-2 as directed at the last meeting, the question of change of title of the Standard Tests for Flash Point of Volatile Paint Thinners, prepared by Committee D-1, to include all volatile inflammable liquids. It was the sense of the Executive Committee that this question should be referred to the enlarged Committee D-2 on Lubricants and Petroleum Products just proposed.

The Secretary-Treasurer presented a report of Committee E-1 prepared in pursuance of directions by the Executive Committee at its last meeting.

Voted, to receive this report as one of progress, and to instruct Committee E-1 to hold a meeting which the chairmen of each standing committee in the Society shall be directed to attend or to appoint a representative from the Committee, and that at this meeting shall be considered the proposed reorganization of Committee E-1 with a view of presenting a final report to the Executive Committee at its next meeting. The Secretary-Treasurer was directed to see that the wishes of the Executive Committee are carried out, and to represent the Executive Committee at the meeting.

The Secretary-Treasurer reported that Committee A-1, acting in cooperation with the Bureau of Standards and the United States Railroad Administration, had prepared a tentative program of investigation of the effect of phosphorus and sulfur on steel, with particular reference to the requirements in the A.S.T.M. Specifications; and presented the following resolution on behalf of the Committee:

> "*Resolved*, That the Executive Committee be requested to invite the Bureau of Standards, The United States Railroad Administration, other consumers, and the Association of American Steel Manufacturers to appoint representatives to serve with representatives of the A.S.T.M. on the proposed joint committee on investigation of phosphorus and sulfur, each group to appoint not more than two representatives."

Voted, that the Executive Committee approves of the proposed investigation on phosphorus and sulfur, and that the request of Committee A-1 be referred to a committee to be appointed by the President, to which committee shall be given authority to extend invitations to the organizations named and to such others as may seem desirable.

The Secretary-Treasurer presented the recommendation contained in the annual report of Committee C-7 on Lime that the standard testing sieves promulgated by the Bureau of Standards be adopted by the Society. It was voted that the Executive Committee approves in principle the use of a single series of standard testing sieves throughout the standards of the Society, and that the Secretary-Treasurer be directed to advise all standing committees involved of this fact and to request their careful consideration of the adoption of the series of standard sieves promulgated by the Bureau of Standards.

The Secretary-Treasurer presented to the Executive Committee the following question referred to the Executive Committee by the Society at the recent annual meeting: "Shall standard specifications for materials include requirements covering such matters as application, workmanship and recommended practice in general?"

It was explained that this matter came up in connection with the proposal of Committee C-11 to include in proposed Specifications for Gypsum Plasters, matters involving application and erection of plasters and certain other features which seemed to constitute recommended practice rather than requirements in material specifications. It was voted to refer this matter to a committee to be appointed by the President.

The Secretary-Treasurer stated that the appointment of sub-committees of the Executive Committee to give consideration to a variety of matters between the quarterly meetings of the Executive Committee would greatly expedite the business at those meetings and would result in quicker action on the subjects referred to such sub-committees. It was accordingly voted to appoint three standing committees of the Executive Committee: (1) On Inter-Society Relations, (2) On Inter-Committee Relations, (3) On General Subjects; and that the President be given power to appoint special committees on any subject requiring consideration between the meetings of the Executive Committee.

The Secretary-Treasurer presented the following resolution adopted by Committee C-7 on Lime:

> "That, whereas, sand is a material used broadly for construction purposes, and, whereas, nearly all of the 'Group C' committees of the Society are interested in, and have to deal with the question of sand as an admixture with the material over which each committee has jurisdiction, the Executive Committee be requested to instruct all standing committees interested in sand to elect sub-committees on this material; and that the Executive Committee be requested to create a standing Committee on Sand to be composed of one delegate from each of the above mentioned sub-committees."

Voted, to refer this resolution to the Committee on Inter-Committee Relations, with the suggestion that they arrange for a meeting of the several committees interested in this subject.

The Secretary-Treasurer reported that the translation of A.S.T.M. Standards into French by the U. S. Department of Commerce has been gotten under way, the Department having placed this work in the hands of Mr. C. O. Mailloux. He stated further that he has submitted a desired order of translation of the specifications similar to that prepared for translation into Spanish, and has suggested to the Department of Commerce that some sixteen specifications adopted as standard since the Spanish translation was completed, be included in the list for translation into French.

Voted, to request the special Committee on Translation of Standards to communicate with the chairmen of standing committees concerned to ascertain whether the specifications which are to be translated into French harmonize with similar specifications of other organizations.

On motion, the Executive Committee approved the appointment made by the President of Mr. A. E. Phillips, Sanitary Engineer, Division of Sanitary Engineering, District of Columbia, as the second representative of the Society on the Joint Concrete Culvert Pipe Committee.

On motion, the Executive Committee approved the appointment made by the President of the Secretary-Treasurer as the representative of the Society on the Conference on Technical Symbols.

The Secretary-Treasurer reported that the American Foundrymen's Association at the suggestion of the Society had agreed to assume the sponsorship of a joint committee to establish standard core prints, pattern colors, allowances in castings, etc., and that that Association was forming such a joint committee to consist of two representatives from each of the following societies: American Foundrymen's Association, National Association of Pattern Makers, Steel Founders' Society of America, American Malleable Castings Society, Metal Division of the A.I.M.E., and the American Society for Testing Materials.

On motion, the appointments of the two A.S.T.M. representatives on this joint committee were left with power to the President and Secretary-Treasurer.

The Secretary-Treasurer presented a report on behalf of the committee consisting of Vice-President Geo. S. Webster, Mr. Ernest Ashton and the Secretary-Treasurer, appointed at the last meeting of the Executive Committee to report upon a plan of organization for the Joint Committee. With certain amendments in Paragraphs (*D*) and (*F*), the plan was approved, and follows in revised form:

"The Committee held a meeting at the Engineers' Club of Philadelphia on Monday, August 4, at which, upon invitation, Mr. Richard L. Humphrey, Chairman of Committee C-2 on Reinforced Concrete, and Mr. S. T. Wagner, Secretary of that Committee, were present. The Committee studied carefully the more important considerations affecting the organization and conduct of activities of the proposed Joint Committee on Specifications for Reinforced Concrete, and prepared the following statement as a basis of organization of the Joint Committee:

"(*A*) *Object of the Joint Committee.*—The Joint Committee is to be created for the object of preparing standard specifications for Reinforced Concrete.

"(*B*) *Basis of Representation of Cooperating Bodies.*—It is fundamental that each cooperating body shall have equal representation on the Joint Committee. It is proposed that the Joint Committee shall consist of five representatives from each of the following five societies: American Society of Civil Engineers, American Railway Engineering Association, American Concrete Institute, Portland Cement Association, and American Society for Testing Materials, these being the five societies which were represented on the former Joint Committee. It is considered that a committee of twenty-five as thus formed is of about the proper size effectively to conduct committee work of the nature proposed, and is preferable to a committee of fifteen or twenty.

"(*C*) *Organization of Joint Committee.*—Following the appointment of representatives of each cooperating body, the proposed Joint Committee shall hold a meeting for purposes of organization, at which officers of the committee shall be elected and Rules of Procedure formulated, the latter to be submitted to the cooperating bodies for approval. These Rules should include such questions as meetings of the Committee, conduct of letter ballot votes, presenting of reports, disbursement of any funds in its charge, etc.

"(*D*) *Reports of Joint Committee.*—It shall be understood that the Joint Committee shall not itself publish any reports. It shall submit its reports to the cooperating bodies, who may individually publish such reports in their customary manner.

"The initial report of the Joint Committee shall be considered by each cooperating body as a tentative report submitted for criticism and discussion, for which not less than six months nor more than one year shall be allowed. Such discussions shall then be referred to the Joint Committee for its consideration in revising its report.

"(*E*) *Right of Independent Action Reserved.*—It is understood that each cooperating body reserves the right to independent action upon the report of the Joint Committee.

"(*F*) *Financial Support of Committee Work.*—Financial support by the cooperating bodies of the work of the Joint Committee shall be limited initially to the sum of $500, of which it shall not be obligatory for any one cooperating body to contribute more than $100. This fund shall be applied only to the payment of expenses for stationery, postage and clerical work, including the duplication of minutes, etc.; and shall be disbursed in a manner to be described in the above mentioned Rules, which are subject to the approval of the cooperating bodies.

"The Joint Committee shall not be authorized to make expenditures beyond the amount appropriated, nor shall additional funds be solicited in any manner without the prior approval of the cooperating bodies.

"(*G*) *Life of the Joint Committee.*—The Joint Committee may be dissolved by joint action of the cooperating bodies, provided, however, that its existence shall not be terminated prior to the adoption of its final report by each of the cooperating bodies, in order that it may be in a position to consider any criticisms of that report which may be made by any of the cooperating bodies.

"This statement was submitted to the four Societies which had been invited to cooperate with the A.S.T.M. in the organization of the proposed Joint Committee, viz: American Society of Civil Engineers, American Railway Engineering Association, American Concrete Institute, Portland Cement Association."

The special committee making the report was continued, and the appointment of the five representatives of the Society was left with power to the President, with the suggestion that the advice of the special committee be obtained.

The Secretary-Treasurer reported that three committees of the Society: namely, A-1 on Steel, A-2 on Wrought Iron and A-7 on Malleable Castings, were cooperating with the Track Committee of the American Railway Engineering Association in the consideration of proposed revisions in the specifications of the Association for various track accessories.

The committee appointed on the subject of cooperation with the Mechanical Section, American Railroad Association: namely, President Capp, Past-President Stevenson and the Secretary-Treasurer, reported that their invitation to the Mechanical Section, A. R. A., to appoint a committee to confer with a committee of this Society on matters common to the fields covered by the two organizations, had been favorably received and that the Mechanical Section had appointed as their Conference Committee, Mr. A. W. Gibbs, Chairman, Mr. C. B. Young and Mr. H. V. Hawthorne. The Committee further reported that Mr. C. B. Young, Manager, U. S. Railroad Administration, Inspection and Test Section, had appointed a committee of three to represent the U. S. Railroad Administration in this conference, namely: Messrs. F. M. Waring, J. R. Onderdonk and H. E. Smith.

On motion, the report of the committee was accepted, and the committee continued with the authorization to confer with the committees of the Mechanical Section, A. R. A., and the U. S. Railroad Administration.

The Secretary-Treasurer reported that at his request Mr. H. V. Wille, formerly Chairman of the recently disbanded A.S.T.M. Committee on Pipe Threads, had represented the Society at a public hearing on International Standard for Pipe Threads held on October 2 by the Committee on Pipe Threads of the American Society of Mechanical Engineers. A brief report from Mr. Wille was received and placed on file.

The Secretary-Treasurer presented a report from Mr. Henry M. Howe, who had acted as the Society's representative while abroad recently in an endeavor to interest British and French engineering circles in the organization of an International Society for Engineering Materials, to take up and broaden the work of the now defunct International Association for Testing Materials. Mr. Howe stated that two conferences had been held at the Institute of Civil Engineers in London regarding the desirability of forming such an International Society and that the action at the last conference could be briefly summarized by the following resolutions:

> "That the question for forming an International Association be postponed for the present.
>
> "That it is advisable to take steps to form a National Association to investigate the properties of materials, and that the different technical societies be asked to take the formation of such an association into careful consideration.
>
> "It was felt that this latter resolution would not in any way interfere with the activities of the British Engineering Standards Association, as the question would go before the six Institutions which had founded the Association, and that they would give careful consideration as to whether the work should be carried out by a separate organization, or whether on the other hand it would be preferable for it to be carried out under the auspices of the British Engineering Standards Association."

The Secretary-Treasurer presented correspondence with the Hotel Traymore, Atlantic City, N. J. After some discussion it was voted that the question of time and place for holding the next annual meeting be referred to a special committee, with directions to report to the Executive Committee at its next meeting unless conditions should be such that an earlier decision in the matter is imperative.

REGULAR MEETING, January 22, 1920.—Engineering Societies' Building, New York City. Present: President, J. A. Capp; Vice-Presidents, G. S. Webster, C. D. Young; Past-Presidents, A. A. Stevenson, Gen. W. H. Bixby, G. H. Clamer; Members of Executive Committee, G. Aertsen, E. Ashton,

G. K. Burgess, H. F. Moore, C. F. W. Rys, Capt. W. J. Baxter, representing Admiral D. W. Taylor; Secretary-Treasurer, C. L. Warwick; Assistant Treasurer, J. K. Rittenhouse.

The Secretary-Treasurer reported that favorable action had been taken on 61 new applications for membership, that 53 had resigned and that the Society had suffered the loss through death of 2 members, making the total membership in the Society on December 31, 1919, *2572*. On motion, this report was accepted and ordered spread on the minutes.

The Secretary-Treasurer presented the quarterly financial report, which was, on motion, accepted and ordered spread upon the minutes.

Auditors' Report for 1919.—The Secretary-Treasurer presented the Auditors' report for 1919, which was on motion approved and ordered spread upon the minutes.

Budget for 1920.—The report of the Finance Committee presenting the proposed budget for 1920 was submitted.

Voted, that the report be accepted and the budget approved with the understanding that the Finance Committee is authorized to make transfers and changes in the distribution of the items in the budget.

Voted, that the question of the necessity of securing a Technical Assistant and the determination of the time at which he should be secured, if one is necessary, be left with power to the Finance Committee and the two Vice-Presidents.

Report of Committee on Headquarters.—The Committee on Headquarters presented a report in the form of a letter to the President dated January 19, 1920, which was accepted with the understanding that certain revisions based upon information not in the hands of the committee prior to the meeting would be made.

The Committee on Headquarters was discharged with thanks for the services it had rendered.

INTER-SOCIETY AFFAIRS.

Report of Committee on Inter-Society Relations.—The report of this committee was presented by its Chairman, Past-President A. A. Stevenson.

At the last meeting of the Executive Committee it was "voted that the Executive Committee approves of the proposed investigation of phosphorus and sulfur in steel, and that the report of Committee A-1 be referred to the Committee on Inter-Society Relations, which shall be given authority to extend invitations to the organizations named, and to such others as may seem desirable."

In pursuance of this authorization invitations were extended to nine organizations, in addition to the Society, from whom acceptances were received in each instance. The committee was accordingly organized on November 29, at a meeting called by the Committee on Inter-Society Relations, at which the chairman of that Committee presided until the Joint Committee had effected a permanent organization.

The Committee on Inter-Society Relations believes that the Joint Committee as at present constituted is thoroughly representative and has made a very fair start upon a problem of great importance and magnitude.

The report of the committee was accepted.

Report of Committee on Cooperation with American Railroad Association.—The report of this committee was presented by its Chairman, President J. A. Capp.

The Committee on Cooperation with the American Railroad Association was directed at the June, 1919, meeting of the Executive Committee to confer with the Mechanical Section, A. R. A., and the U. S. Railroad Administration concerning the desirability of establishing a basis of cooperation between those three bodies in the preparation of standards for railroad materials.

Two conferences have been held, as a result of which an Outline of Method of Cooperation proposed by your representatives has been adopted as a tentative basis of cooperation. This is given below in the exact form in which it was agreed upon; and if approved by the Executive Committee, it seems to your committee desirable that it should be rewritten in a form suitable for incorporation in the Regulations Governing Standing Committees.

OUTLINE OF METHOD OF COOPERATION APPROVED AT A CONFERENCE OF REPRESENTATIVES OF THE A.S.T.M., MECHANICAL SECTION, A. R. A., AND U. S. RAILROAD ADMINISTRATION.

I. *Joint Preparation of New Standards.*

In the consideration of the preparation of new standards it is suggested that each organization will appoint representatives to a joint committee, such that the joint committee will be fairly representative of all interests concerned. Such a joint committee might operate along the following lines:

1. The A.S.T.M. representatives on the Joint Committee would correspond in effect to our present sub-committees of a standing committee; or in some instances, perhaps, to a standing committee itself.

2. The officers of the Joint Committee should be elected by the committee itself.

3. The reports of the Joint Committee should be submitted to the proper authorities in each cooperating body, with the understanding that each such body reserves the right to independent action.

4. It is believed, however, that the joint committee should be given an opportunity of considering any revision in its report suggested by either of the cooperating bodies before those bodies take final action.

5. In so far as the A.S.T.M. is concerned, the *modus operandi* would be about as follows: The A.S.T.M. Representatives on the Joint Committee being in effect a sub-committee of one of the standing committees of the Society, those representatives would present the report or specifications of the joint committee to that standing committee, which would take action in accordance with the provisions of the Regulations Governing Standing Committees of the Society. If the standing committees desired to revise the report, it would indicate such revisions and refer the report back to its representatives on the joint committee with directions to present the proposed revisions to the joint committee for its consideration. After such consideration the report would again go before the standing committee for submission ultimately to the Society for action.

II. *Joint Harmonizing of Existing Specifications.*

In the consideration of harmonizing existing specifications, it is proposed that joint committees such as that above outlined be formed on which, in so far as the A.S.T.M. is concerned, it is our thought that existing sub-committees of the A.S.T.M. on the respective specifications would as a general proposition be appointed by our Executive Committee as our representatives on the proposed joint committee.

At the second conference meeting there was discussed the question of the desirability of indicating on any standard adopted by the A.S.T.M. Mechanical Section, A. R. A. and the Railroad Administration as a result of joint committee work, in some appropriate form, the fact that the same specification has been adopted by these three bodies. The policy of the Society in the past has been to give a complete history of the preparation of a standard in the report of the committee which prepared it, but that when the standard was adopted, it was published as an A.S.T.M. standard without any notation as to how it was prepared nor by whom it may also have been adopted. Your committee believed that this matter might well receive the consideration of the Executive Committee at its next meeting.

Problems to be Gotten Under Way Under this Plan of Cooperation.—There are several lines along which cooperation such as outlined above should be taken up, promptly; for example, specifications for steel castings for locomotives and cars, specifications for cast iron car wheels, specifications for rolled steel wheels and tires, and specifications for non-ferrous alloys for railroad equipment.

A tentative beginning has already been made on the first of these, namely, the creation of a Joint Committee on Specifications for Steel Castings for Locomotives and Cars.

In order that your committee may be in a position to confer with the other two cooperating bodies on any matters which may arise as the details of the cooperative plan are worked out, your committee recommends that it be continued.

The Outline of Method of Cooperation approved at a conference of representatives of the Society, the Mechanical Section A. R. A. and the U. S. Railroad Administration, included in this report, was approved.

Voted, that the Executive Committee approves in principle the policy of indicating on the first page of Standards which have been prepared in cooperation with other bodies and adopted jointly, in some appropriate form, the fact that such Standards have been so prepared and adopted; and that the Committee on cooperation with American Railroad Association be directed to request the Conference Committee to make recommendations as to the form which this recognition shall take.

It was the sense of the meeting that the above action is applicable to all cooperative work in which the Society engages, including joint sponsorship under the American Engineering Standards Committee.

A request of Sub-Committee VII on Steel Wheels and Tires of Committee A-1 on Steel, that there be created a joint committee with the Mechanical Section A. R. A. and the U. S. Railroad Administration on the subject of wheels and tires was presented. It was explained that this request was being made by Sub-Committee VII direct, and not by Committee A-1, with the approval of the Chairman of that Committee, Mr. F. M. Waring, in order to save time. On motion, it was

Voted, that the Secretary-Treasurer be directed to bring the request of Sub-Committee VII to the attention of the Conference Committee with the request that this work be taken up as soon as possible.

The Committee was continued and empowered to act in matters of appointments on joint committees with the Mechanical Section A. R. A. and the U. S. Railroad Administration, subject to approval of the Executive Committee.

Report of Committee on Organization of Joint Committee on Specifications for Reinforced Concrete.—The report of the Committee was presented by Vice-President Geo. S. Webster.

Your committee met on November 26, 1919, to prepare recommendations for the consideration of President Capp as to the name of the five representatives of the A.S.T.M. on the proposed Joint Committee on Specifications for Reinforced Concrete. The committee recommended the following appointees to the President:

Richard L. Humphrey	H. H. Quimby
L. S. Moisseiff	A. T. Goldbeck
E. E. Hughes	

The President appointed these gentlemen as our representatives, and acceptances have been received from all of them.

All five of the proposed cooperating bodies have now appointed their representatives.

The personnel shows eleven representatives of producing interests, eleven representatives of consuming interests, and three representatives of general interests, so that the joint committee as thus organized would conform with the Rules laid down by the American Engineering Standards Committee. This seems to your committee to be an important point because the work of the joint committee, which is unquestionably thoroughly representative, may come ultimately before the Standards Committee for approval.

Your committee recommended to President Capp that in its opinion it would be desirable for the organization meeting of the joint committee to be called by the Secretary-Treasurer on behalf of the Executive Committee, and that the meeting should be presided over by an officer of the joint committee until the joint committee has been formally organized and its officers elected. President Capp has approved this recommendation of your committee, and has designated Vice-President Webster (a member of your committee) to preside at the organization meeting on behalf of the Executive Committee.

On motion, the report was approved and the action of the President in requesting Vice-President Webster to preside, on behalf of the Executive Committee, at the organization meeting of the Joint Committee on Specifications for Reinforced Concrete pending its formal organization, was confirmed.

American Engineering Standards Committee.—The Special Committee on Rules of Procedure and By-Laws of the Standards Committee presented a report recommending (1) that the Rules of Procedure adopted by the American Engineering Standards Committee on November 22, 1919, be approved by the Executive Committee without amendment; (2) that the By-laws of the Standards Committee adopted on the same date be approved and (3) that the following recommendations be made by the Executive Committee to the Standards Committee concerning the By-laws:

Section 12.—Change the word "representatives," second line, to "members."

Section 15.—Change the provision that "No business not in the calendar shall be considered until the calendar has been disposed of," so that by unanimous consent business on the calendar may be suspended for other business.

Section 23.—Change the word "approve" to "supervise."

Article VIII.—Include some provision in this article which will prevent a special committee of the Standards Committee to whom a given standard may have been referred, from unduly delaying action upon that standard. It is suggested that a limit of six months be placed upon the time which such a special committee may hold a standard which has been submitted by a sponsor to the Standards Committee.

Voted, that the recommendation of the committee be approved and the Secretary-Treasurer directed to bring the suggested revisions of the By-Laws to the attention of the Standards Committee; and that the committee be continued as a Special Committee on general matters relating to the Standards Committee.

Voted, that the alternates to the representatives of the Society on the Standards Committee shall be the Secretary-Treasurer, Mr. G. Aertsen and Mr. C. D. Young, and that in case of necessity for any of these to act as alternates the Secretary-Treasurer shall send sufficient notice to the Secretary of the Standards Committee.

Voted, that "stickers" be prepared for distribution among the members of the Society and use in all copies now on hand of the Book of Standards, including separate reprints, indicating the fact that Standard Specifications C 9 - 17 and C 19 - 18 were adopted by the Standards Committee as Tentative Standards on March 1, 1919: and that such information be included in some appropriate form on the first page of all specifications to which it applies in the future.

The Secretary-Treasurer presented a letter from the Standards Committee under date of January 14, formally advising the Executive Committee that the Standards Committee at its meeting on January 8, 1920, had voted to admit to membership the National Safety Council (as representing the Safety Group) with three representatives and the Fire Protection Group, consisting of the National Fire Protection Association, the National Board of Fire Underwriters and the Associated Factory Mutual Fire Insurance Cos. with three representatives; in each instance the action having been taken by a unanimous vote.

Voted, to approve the election of the National Safety Council and the Fire Protection Group to membership in the Standards Committee.

Engineering Council.—Report of Mr. Albert Ladd Colby, representative on Engineering Council, was read in full by the Secretary-Treasurer and, on motion, accepted and ordered filed. An informal discussion of the work of Engineering Council was held.

The Secretary-Treasurer presented correspondence with, and a report of, a Government Committee which had been charged with the duty of preparing the specifications for the classification of "Materials Engineers" in federal employment in the District of Columbia, with which committee the Secretary-Treasurer and Mr. S. V. Hunnings had sat as representatives of the Society.

The suggestion was also presented that the A.S.T.M. consider defining the term "Materials Engineering."

On motion these matters were referred to the Committee on Inter-Society Relations.

The Secretary-Treasurer presented certain correspondence with the President relating to the personnel of our committee to cooperate with the A.S.M.E. Boiler Code Committee.

Voted, that the Secretary-Treasurer, Mr. C. F. W. Rys and Mr. F. J. Cole be appointed a Committee of the Society to confer with a similar committee of the A. S. M. E. Boiler Code Committee on all matters relating to the use of A.S.T.M. Standards in the Boiler Code, with the understanding that the committee has the privilege of taking into conference any other members of the Society whenever it is deemed necessary.

The committee consisting of Messrs. Capp, Rys and Stevenson, appointed at the meeting of the Executive Committee in April, 1919, to confer with the Society of Automotive Engineers as to cooperation in standardization of aircraft materials, reported that the Society of Automotive Engineers have advised that they will participate in the work of the American Engineering Standards Committee, thus furnishing an adequate channel for the desired cooperation. On motion the report was accepted.

The action of the President in appointing Mr. J. C. Davis and Mr. G. Correy as representatives of the Society on the Joint Committee on Standard Pattern Practice, was, on motion, approved; and the Secretary-Treasurer was directed to suggest to the American Foundrymens' Association, which is acting as sponsor for this committee, that it advise the American Engineering Standards Committee of the creation of the Joint Committee.

A.S.T.M. COMMITTEE AFFAIRS.

Report of Committee on Inter-Committee Relations.—The report of the committee was presented by its Chairman, Vice-President Young.

The Committee on Inter-Committee Relations begs to report as follows concerning three questions; the first two having been referred to it at the last meeting of the Executive Committee, and the third by the Secretary-Treasurer since that time.

1. *Shall Questions of Application, Workmanship and Erection be Included in Specifications for Materials?* This question was raised at the annual meeting in connection with the proposed specifications for gypsum plaster submitted by Committee C-11 on Gypsum. Your committee held a hearing on this subject on December 11, at which were present three of the officers of Committee C-11, and several members of the Society who at one time or another had shown an active interest in this subject. At this hearing a file of correspondence on the subject, obtained at the solicitation of the Secretary-Treasurer was read in full and a comprehensive discussion of this subject was had.

Your committee accordingly recommends, first, that the Executive Committee reaffirm the requirements in Section 14 of the Regulations Governing Standing Committees relating to "Matters of Engineering Design;" second, that it does not appear, with respect to the specifications for gypsum plasters in question, that the consideration of application, workmanship, erection or recommended practice in general is "indispensable in specifications designed to cover the customary relations between the producers and consumers of a given product," that product being in this instance gypsum plaster ready for application, and that therefore, these considerations should not be included in the specifications for gypsum plasters; third, that this interpretation of Section 14 of the Regulations shall be communicated to Committee C-11 and brought to the attention of the Society through the next annual report of the Executive Committee, to serve as a precedent in the consideration of similar problems in other committees.

2. *Recommendation of Committee C-7 on Lime that there be Created a Standing Committee on Sand.*—Your committee took advantage of the fact that a meeting of Committee E-5 was held on December 11, to request their consideration and advice on the recommendation of Committee C-7 to create a standing committee on sand, inasmuch as there were present at the meeting of Committee E-5 the chairman of most of the committees of the Society that deal with sand as a material. After careful consideration Committee E-5 passed the following resolution by a vote of 12 affirmative and five negative:

> "*Voted* that it is undesirable to create a separate standing committee on sand as suggested by Committee C-7, and that if any committees of the Society concerned with specifications for sand desire, the present machinery of the Society provides a satisfactory means of discussing matters of common interest through the formation of a conference committee on which each standing committee concerned would be represented."

This resolution has received the consideration of your committee and we unanimously endorse it for the favorable consideration of the Executive Committee.

3. *Recommendation of Committee C-11 that some Satisfactory Means be Provided for Cooperation on Questions of Nomenclature.*—This question was referred to your committee by the Secretary-Treasurer in pursuance of a request which he had received from Mr. W. E. Emley, Chairman of Committee C-11, that an official basis of cooperation on the subject of nomenclature be established between certain committees of the Society that were concerned with definitions of terms relating to the gypsum industry.

This subject was also referred to Committee E-5 for consideration and advise. Your committee believes that a standing committee on nomenclature should be created to consist of representatives from the standing committees, and that the Secretary of the Society should be a member of this committee; that the functions of this committee should be to receive the recommendations concerning nomenclature and definitions from the various committees of the Society and either to approve them or refer them back to the originating committee with such suggestions and modifications as seem necessary; to act as a correlating committee in all work on this subject and to furnish a means for committees working on allied subjects to work together on matters of definitions; also to act in general as an editing committee on definitions. Each standing committee should be entitled to one representative on the proposed standing committee on nomenclature, who should preferably be the chairman of the sub-committee on nomenclature of the standing committee.

On motion, the report and recommendations of the committee were approved.

The Secretary-Treasurer reported that a conference of Committee E-1 with the Chairmen of standing committees was held on December 12 as directed by the Executive Committee and that a special committee appointed at that meeting is now preparing a plan of reorganization for submission to a second conference; and that a final report will be made at the next meeting of the Executive Committee.

The Secretary-Treasurer presented the recommendation of a special committee to the President that Committee E-6 on Papers and Publications, inasmuch as it is the only strictly administrative committee of the Society for which there is no provision for change in personnel, be requested to consider some plan of organization by which its personnel should change periodically; for example, by having the terms of office of a certain proportion of its membership expire at definite fixed periods.

Voted, to refer this matter to Committee E-6 with directions to report back to the Executive Committee with its recommendations.

The Secretary-Treasurer stated that he had received correspondence on the subject of the proposed discharge of Committee A-4 on heat treatment of iron and steel from the Chairman and Secretary of Committee A-4.

Voted, that this matter be referred to the Committee on Inter-Committee Relations.

The Secretary-Treasurer stated that he had secured a favorable response from the Bureau of Standards in answer to an inquiry as to whether the bureau would be willing to assist in the creation of a committee on Wire Cloth; and recommended that he be authorized to call a conference of interested parties to determine whether it is desirable for the Society to organize such a committee. On motion this recommendation was approved and it was suggested that representatives of the American Railroad Association be invited to attend the conference.

MISCELLANEOUS ITEMS.

The Secretary-Treasurer presented the report of the tellers, Messrs. M. E. Hibbs and S. C. Hollister on recommendations for appointments on the Nominating Committee for Officers, the complete report being available in full detail for reference purposes.

Voted, that in addition to the last three Past-Presidents, Messrs. Stevenson, Bixby and Clamer, who are ex-officio members of the Nominating Committee, the following appointments on that committee be made:

Members	*Alternates*
Unger, J. S.	Morrow, J. G.
Boyer, E. D.	Greenman, R. S.
Waring, F. M.	Gibboney, J. H.
Blanchard, A. H.	Goldbeck, A. T.
Shelley, H. T.	Bleininger, A. V.
Gardner, H. A.	Walker, P. H.

The Secretary-Treasurer stated that the Committee on Annual Meeting had transmitted a report by letter to the Executive Committee under date of December 23 recommending that the Annual Meeting be held at the New Monterey Hotel, Asbury Park, N. J. during the week of June 21, 1920, and that that recommendation had been approved by letter ballot vote of 14 affirmative, 1 not voting. A total number of 12 votes having been required for adoption in accordance with the action of the last meeting, the Secretary-Treasurer had announced the week and place of meeting in Circular No. 151 to Members dated January 1, 1920.

Voted, that the Annual Meeting be held from June 22 to June 25 inclusive, and that the time which has heretofore been devoted to a reception should be given over to a business session until ten o'clock to be followed by a dance or other entertainment to be provided by the Entertainment Committee.

Voted, to appoint Mr. E. D. Boyer as Chairman of the Entertainment Committee, other appointments to be left with power to Mr. Boyer and the Secretary-Treasurer.

The Secretary-Treasurer presented an abstract of correspondence with Mr. R. S. Greenman, Chairman of Committee C-1 on Cement, and President Capp, from which it had appeared that the Government had given notice that after January 1, 1921, it would increase the fineness requirements in Government Specifications, without apparently having given Committee C-1 an opportunity to present certain data on the subject, notwithstanding the fact that the Government Specifications and the A.S.T.M. Specifications are at present identical and were prepared in cooperation.

Voted, that a special committee be appointed consisting of Vice-President Webster, the Secretary-Treasurer and the Chairman of Committee C-1 to confer with the proper Government officials, and to point out the desirability of giving due consideration to the investigations of Committee C-1; the committee to report to the Executive Committee at the next quarterly meeting.

Vice-President Young, who represented the Society at the Industrial Safety Conference held at the Bureau of Standards, Washington, D. C., December 8, 1919, presented a report of the conference in the form of a document issued by the Bureau of Standards entitled, "Condensed Report of Industrial Safety Conference."

The Secretary-Treasurer reported that he had conferred with Colonel L. H. Ruggles of the Technical Staff, U. S. Ordnance Department, concerning the best means of establishing cooperation between the Society and the Technical Staff. Colonel Ruggles has expressed the desire that the Technical Staff shall affiliate itself with various technical societies as soon as necessary laws are passed by Congress permitting them to do so. The Secretary-Treasurer explained to Colonel Ruggles that the Society would be glad to receive offers of technical papers from the Technical Staff on subjects of interest to our members.

The Secretary-Treasurer presented a letter from Colonel Ruggles requesting endorsement by technical societies of the program of work contemplated by the Technical Staff.

Voted, that the Secretary-Treasurer acknowledge this letter stating that the Executive Committee is in sympathy with the program of work outlined.

The Secretary-Treasurer presented an abstract of correspondence with President Capp and Mr. D. E. Douty relating to the representation of the Society on a National Cotton Research Committee. He also presented the following resolution adopted by Committee D-13 on Textile Materials:

> "*Whereas*, the Committee on Research, Reports and Statistics of the World's Cotton Conference assembled in New Orleans, Oct. 12–16th, submitted a unanimous report to the General Committee of the Conference recommending the establishment of a National Committee for Cotton Research in the United States one member of which was to be designated by the President of the American Society for Testing Materials; be it

"*Resolved*, that Committee D-13 recommend to the President and Executive Committee of the American Society for Testing Materials in case a request for duch designation is received by the Society that the present Chairman of the Committee D-13, Mr. Geo. B. Haven be appointed to represent the Society."

Voted, that this matter be referred to the Committee on Inter-Society Relations, with the understanding that if and when the Society is asked to appoint a representative on a National Cotton Research Committee, Mr. G. B. Haven will be appointed such a representative.

The Secretary-Treasurer reported that President Capp had appointed Mr. S. S. Voorhees to represent the Society at the Second National Public Works Department Convention held in Washington January 13–14, and presented a report from Mr. Voorhees; which on motion, was received and ordered filed with an expression of appreciation to Mr. Voorhees for his services.

The Secretary-Treasurer presented correspondence with Mr. Arthur M. Greene relating to joint publication by Engineering Division of National Research Council and Engineering Foundation of information concerning these two bodies for the purpose of interesting various people in their work.

In view of the fact that such a joint publication has already been issued, this correspondence was, on motion, laid on the table.

The Secretary-Treasurer presented correspondence with Mr. E. P. Hyde of the National Research Council asking for the moral support of the Society on the project of the National Research Council to prepare and publish more critical tables of physical and chemical constants than are at present available. It was explained that the National Research Council will endeavor to secure the funds for this publication from the various industries which would benefit by it.

Voted, that the Secretary-Treasurer be directed to reply that the Society endorse this project, and that copies of the correspondence be sent to Mr. C. A. Adams, Chairman of the Engineering Division of the National Research Council.

The Secretary-Treasurer presented a letter from Mr. L. H. Provine, Chairman of Committee C-10 on Hollow Building Tile, giving the personnel of a reorganized committee which has been under consideration for over a year.

Voted, that the proposed personnel be approved and the Secretary-Treasurer authorized to invite those interested to membership on the reorganized committee.

The Secretary-Treasurer presented a communication from Mr. J. A. Newlin, Chairman of Committee D-10 on Shipping Containers, suggesting the adoption of a "schedule" for the nailing of boxes. On motion, this was referred to the Committee on Inter-Committee Relations.

The Secretary-Treasurer presented a letter inquiring as to the policy of the Society with regard to the specifying of patented apparatus in standards of the Society and instancing in that connection the specifying of the Tag Closed Flash Point Tester adopted by Committee D-1 on Preservative Coatings for Structural Materials and the Saybolt Universal Viscosimeter adopted by Committee D-2 on Lubricants.

Voted, that this matter be referred to the Committee on Inter-Committee Relations; and that the correspondent be advised of this action and his attention called to Article VI, Section 2 of the By-Laws relating to "Standards Involving Patents."

Past-President Stevenson presented the following petition bearing the names of ten members recommending the election of Professor Gaetano Lanza to Honorary Membership:

> "The undersigned beg leave to propose Professor Gaetano Lanza for Honorary Membership in the Society. It is believed that he eminently meets the qualifications for Honorary Membership defined in the by-laws of the Society. He has attained widely recognized eminence in the field of engineering materials, and we believe that this recognition of his attainments and of the effective service which he has rendered to the Society for many years, would be most fitting."

Voted, that Professor Lanza be nominated to Honorary Membership in the Society, and that his election be submitted to a letter ballot of the Executive Committee, as required by the By-Laws.

REGULAR MEETING, April 13, 1920.—A.S.T.M. Headquarters, Philadelphia, Pa. Present: President, J. A. Capp; Vice-President, G. S. Webster; Past-Presidents, A. A. Stevenson, Gen. W. H. Bixby, G. H. Clamer (arrived 12 o'clock); Members of Executive Committee, G. Aertsen, G. B. Heckel, H. F. Moore, Capt. W. J. Baxter (representing Admiral D. W. Taylor; Secretary-Treasurer, C. L Warwick; Assistant Treasurer, J. K. Rittenhouse.

The Secretary-Treasurer reported that favorable action had been taken on 129 new applications for membership, that 34 members had resigned, that the Society had suffered the loss through death of 3 members and that 65 members had been dropped for non-payment of 1919 dues, making a total membership in the Society on March 31, 1920, *2599*.

The Secretary-Treasurer presented the quarterly financial report, which was on motion accepted and ordered spread on the minutes.

The Secretary-Treasurer made a brief statement of his activities in the matter of increase of membership, referring to a circular letter addressed to the members of the Executive Committee under date of February 24, 1920, asking them to secure at least five new members during the year. He also stated that, with the approval of the President, he was addressing a circular letter to the members of the standing committees requesting their cooperation with the Executive Committee in stimulating the growth of membership in the Society along desirable lines.

An informal discussion of the question of membership increase indicated that the Executive Committee approved of the activities of the Secretary-Treasurer in this respect.

The Secretary-Treasurer reported that a five-year lease had been executed with the Engineers' Club of Philadelphia for the rental of our present headquarters, at $1000 per annum, of which $4467.17 had been paid in advance

The Secretary-Treasurer reported the engagement of Mr. Raymond E. Hess, a graduate of the Department of Civil Engineering of the University of Pennsylvania, as Technical Assistant.

The Secretary-Treasurer submitted the following question to the Executive Committee: "Shall the publications of the Society be advertised in one or two leading technical journals by means of a dignified card of announcement; and shall some effort be made to bring our publications more immediately to the attention of libraries?"

Voted, to authorize the President to appoint a committee of three to report upon this question at the next meeting.

The Secretary-Treasurer announced that the letter ballot vote on the election of Professor Gaetano Lanza to Honorary Membership in the Society was unanimous, as required by the By-Laws, and that he had advised Professor Lanza of his election and had notified the members of the Society of this action in Circular No. 152 dated March 31, 1920. The Secretary-Treasurer then read a letter of appreciation from Professor Lanza.

The report of the Nominating Committee for Officers was presented, nominating the following for officers and members of the Executive Committee:

For President, George S. Webster;

For Vice-President, George K. Burgess;

For Members of Executive Committee, L. G. Blackmer, D. E. Douty, Prevost Hubbard, R. S. Whiting.

The Secretary-Treasurer advised that acceptances had been received from all of the nominees.

The following recommendation from the Nominating Committee was presented:

> "That the By-Laws governing or defining the membership of a firm, technical or scientific society, a teaching faculty or a library or other body holding membership in the A.S.T.M. be so clearly amended and defined as to leave no doubt as to what such Corporation or Society must comply with in order that their representative be given, or entitled to, any privileges of an individual member."

Voted, that the President be authorized to appoint a committee of three to consider these questions; and that the committee be directed to submit a tentative draft of their report to the members of the Executive Committee for criticism, of which due cognizance is to be taken in preparing their final report to be presented at the next meeting of the Executive Committee.

INTER-SOCIETY AFFAIRS.

Report of Committee on Inter-Society Relations.—The committee reported that it had considered the report on Classification of Materials Engineers prepared by a special committee of the Congressional Committee on Compensation and Classification of Engineers, and had also been in communication with the Chairman of the Committee of Engineering Council on the same subject. As a result of its studies the committee recommended that the

Executive Committee approve the general classifications prepared by Engineering Council's Committee as applicable to the field of Materials Engineers.

Voted, to approve this recommendation, with the understanding that the approval does not extend to the question of compensation of engineers.

The committee also reported that it had advised Mr. D. E. Douty, Chairman of the committee to organize a National Cotton Research Committee, that it is awaiting a definite request from the Research Committee when organized to appoint an official representative.

Cooperation with American Railway Engineering Association.—The Secretary-Treasurer presented the following letter from Mr. E. H. Fritch, Secretary of the American Railway Engineering Association:

> "Referring to your letter of May 13, 1919, and also your later communication of November 24, 1919, the Board of Direction has given the suggestion contained in your letter—of closer cooperation in the preparation of specifications for carbon steel rails between your Society and the Committee on Rail of this Association—due consideration.
>
> "At a meeting of the Board of Direction on March 15, the Secretary was instructed to reply to your suggestion to the effect that inasmuch as several members of the Rail Committee of this Association are also affiliated with the Committee on Rail of your Society, both organizations would through such dual representation have the benefit of the advice of such members in this work, and it is therefore the judgment of our Board that the cooperation suggested by you would be obtained through this representation."

The Secretary-Treasurer was directed simply to acknowledge this letter.

Cooperation with Mechanical Section, American Railroad Association.—The Secretary-Treasurer reported that the Joint Committee on Steel Castings for Railroads referred to at the last meeting had been organized and was making satisfactory progress; also that a committee of the Executive Committee has referred to the Mechanical Section the question of forming a Joint Committee on Specifications for Cast-Iron Car Wheels.

Organization of Joint Committee on Specifications for Concrete and Reinforced Concrete.—The committee presented the following report:

The Joint Committee on Specifications for Concrete and Reinforced Concrete was organized in Philadelphia on February 11, 1920, Vice-President G. S. Webster acting as temporary chairman, and the Secretary-Treasurer acting as temporary secretary. The organization proceeded exactly along the lines suggested by the A.S.T.M. and approved by the other four cooperating bodies. The following officers of the Joint Committee were elected:

Richard L. Humphrey (representing A.S.T.M.), Chairman;
J. J. Yates (representing A.R.E.A.), Vice-Chairman;
D. A. Abrams (representing P.C.A.), Secretary-Treasurer.

At its meeting the Joint Committee adopted By-laws which, in accordance with the scheme of organization, are subject to the approval of each of the cooperating bodies. Your committee has examined these By-laws carefully and find they embody every point laid down in the outline of organization adopted by the Executive Committee at its meeting October 14, 1919. The committee accordingly recommends that the By-laws be approved and the Joint Committee so advised.

The committee further recommends that it be discharged, having completed the work assigned to it. Any questions that might come up in the future relating to the work of this Joint Committee would naturally come under the jurisdiction of the Standing Committee on Inter-Society Relations.

Voted, to approve the By-laws of the Joint Committee; and to discharge the special committee on this subject as recommended.

American Engineering Standards Committee.—The Secretary-Treasurer reported that the revisions in the By-laws of the Standards Committee proposed by the Executive Committee at its last meeting have been reported to the Standards Committee, which has referred them together with suggested revisions from other societies to their Committee on Rules.

The Secretary-Treasurer pointed out the desirability of having the Standards Committee adopt the designation "Tentative *American* Standard" instead of "Tentative Standard" as now appears in its Constitution and Rules of Procedure, in order to avoid confusing the latter term with the same term as used by the A.S.T.M. As an illustration he pointed out that the insertion of a note on an A.S.T.M. Standard to the effect that it has been approved by the Standards Committee as "Tentative Standard" is apt to give the impression that the A.S.T.M. Standard has been "demoted" to tentative standard instead of promoted to "Tentative American Standard."

Voted, to direct the Secretary-Treasurer to bring this matter to the attention of the Standards Committee.

The Secretary-Treasurer presented a letter from the Standards Committee under date of March 12, 1920, formally advising the Executive Committee that the Standards Committee at its meeting on March 6, 1920, had voted unanimously to admit to membership the Society of Automotive Engineers with three representatives; the National Electric Light Association, with the understanding that eventually the central power station interests will together constitute a group with three representatives; the Electrical Manufacturers Council, with the understanding that the Electrical Manufacturers interests will together constitute a group of three representatives.

Voted, to approve the election of these three organizations to membership on the Standards Committee.

The Secretary-Treasurer presented a report of a special committee of the Standards Committee on Definition of Group Representation.

Voted, to refer this report to the Committee on American Engineering Standards Committee for criticism and comment, to be sent to the Executive Committee with a copy of the report in advance of the next meeting.

The Committee on selection of A.S.T.M. standards for approval of the American Engineering Standards Committee reported that it had referred the following five standards to the Standards Committee for approval:

Standard Specifications for Drain Tile (C 4 – 16)
Standard Tests for Toughness of Rock (D 3 – 18)
Standard Tests for Penetration of Bituminous Materials (D 5 – 16)
Standard Methods for Distillation of Bituminous Materials Suitable for Road Treatment (D 20 – 18)
Standard Methods for Sampling of Coal (D 21 – 16)

The committee now has under consideration specifications for steel in the charge of Committee A-1 and specifications for non-ferrous metals in the charge of Committees B-1 and B-2.

Engineering Council.—The Secretary-Treasurer stated that our representative on Engineering Council, Mr. Albert Ladd Colby, had been invited to attend this meeting but that owing to the difficult railroad situation he had been unable to be present. In the absence of any formal report from Mr. Colby to the Executive Committee, the Secretary-Treasurer stated that he had attended the annual meeting of Engineering Council held February 19, 1920, and that nothing of special importance to the A.S.T.M. had transpired at that meeting.

The Secretary-Treasurer reported that the letter ballot of the Executive Committee authorized by the President upon the following resolution:

> *Resolved*, That the amount contributed for Engineering Council by each Founder Society shall be $5000 for the year 1920, in place of $3000, as now provided and by American Society for Testing Materials, $1000 instead of $600,

had resulted in a vote of 14 affirmative and one not voting; in pursuance of which the Secretary-Treasurer advised Mr. Flinn that the contribution of the A.S.T.M. to Engineering Council for the year 1920 would be $1000 instead of $600.

The Secretary-Treasurer presented a resolution passed at the meeting of the governing boards of the five member societies on January 23, 1920, relating to increased contributions from the member societies to Engineering Council.

On motion this resolution was laid on the table.

The Secretary-Treasurer presented the following resolution also passed at the meeting above referred to:

> "*Whereas*, This Conference of national engineering societies has considered the recommendations of the Joint Conference Committee of the four Founder Societies, therefore, be it
>
> "*Resolved*, That the Conference adopts in principle that report and requests the Joint Conference Committee to call, without delay, a conference of representatives of national, local, state and regional engineering organizations to bring into existence the comprehensive organization proposed."

The Secretary-Treasurer stated that he understood unofficially that the conference of representatives of engineering organizations referred to in the above resolution was expected to be held in Washington on June 3 and 4.

Voted, that the Society will accept the invitation, when received, to be represented at the said conference.

It was informally agreed that as many members of the Executive Committee as possible would attend this conference. The consideration of the question of electing a second representative on Engineering Council was postponed pending the outcome of the conference just referred to.

The Secretary-Treasurer presented a letter from Mr. M. O. Leighton, Chairman of the National Service Department of Engineering Council, suggesting that the National Service Department be used as a means of keeping engineering organizations in this country in touch with similar organizations abroad.

Voted, to defer consideration of this communication pending the outcome of the above mentioned conference.

Engineering Division, National Research Council.—A report by Past-President Stevenson, the representative on the Engineering Division, covered the following matters:

(*a*) Appointment by the Engineering Division, N. R. C., of Mr. J. H. Hall as their representative on the Joint Committee on Investigation of Phosphorus and Sulfur in Steel.

(*b*) Appointment by the President of Mr. J. M. Darke to represent the Society on the Research Committee on High Speed Tool Steels of the Engineering Division.

(*c*) The Engineering Division has determined not to appoint its own Research Committee on Magnetic Testing of Steel owing to the fact that the A.S.T.M. has a committee with the same object in view, namely, Committee A-8 on Magnetic Analysis.

Voted, to invite the Engineering Division of the National Research Council to appoint a representative upon Committee A-8 on Magnetic Analysis.

(*d*) The desirability of cooperation with the Engineering Division of the National Research Council in the work of their Research Committee on Heat Treatment, preferably through our Committee A-4 on Heat Treatment of Iron and Steel, was discussed. In view of the fact that the continued existence of Committee A-4 is to be considered at a meeting of that committee in the near future, it was

Voted, to leave this matter in the hands of Mr. Stevenson and the Secretary-Treasurer, with the understanding that the Chairman of Committee A-4 would be advised of our desire to cooperate as far as possible with the Engineering Division's Committee.

(*e*) The Secretary-Treasurer explained that since the last meeting of the Executive Committee there had been considerable correspondence in the matter of possible overlapping of the field of our Committee D-4 on Road Materials with that of one of the research committees of the Engineering Division, whose title and purpose had been announced as follows:

> "Committee on Properties and Tests of Road Materials and Their Combinations: Purpose, to investigate the properties of road materials and their combinations, including devising and standardizing tests."

The Secretary-Treasurer reported that he had conferred with the officers of Committee D-4, together with Mr. A. T. Goldbeck and Mr. H. S. Mattimore (the latter being chairman of the research committee in question); from which it appeared that the above title and purpose do not correctly describe the real purpose of Mr. Mattimore's committee, and that the following title is better: "Committee on Highway Problems with Relation to Character and Use of Materials and Their Combinations." Mr. Mattimore stated that it was not the intention of his committee to devise and standardize tests and that the work of his committee would help rather than hinder that of Committee D-4. With this the officers of the committee agreed. Mr. Mattimore furthermore stated that it would be most desirable to have an active representative of the A.S.T.M. on his committee.

Voted, to authorize our representative on the Engineering Division to adjust matters along the lines developed as a result of the Secretary-Treasurer's conference with the officers of Committee D-4.

The Committee on the Question of Fineness Requirements in Specifications for Cement, has formally requested the U. S. Government Departmental Committee to arrange for a conference between the Departmental Committee and the A.S.T.M. for the purpose of discussing completely and in detail the data on fineness in cement that Committee C-1 has accumulated. Request has been acknowledged by Mr. S. W. Stratton, Chairman of the Departmental Committee and has been referred to Mr. A. P. Davis, Chairman of the Government Departmental Cement Committee, with a view of arranging the desired conference.

A.S.T.M. COMMITTEE AFFAIRS.

Report of Committee on Inter-Committee Relations.

(*a*) Proposed Discharge of Committee A-4 on Heat Treatment of Iron and Steel: The committee has considered carefully the correspondence in this matter referred to it by the Executive Committee, in which the Chairman and Secretary of Committee A-4 stated that a number of members of the committee believed that it should be discharged. After careful consideration, the committee came to the conclusion that there is a distinct field of usefulness in the Society for a Committee on Heat Treatment of Iron and Steel, and in a letter to Mr. J. H. Hall, Chairman of Committee A-4, recommended that the question of discharge of the committee be resubmitted to Committee A-4 at a meeting at which, if desired, the Executive Committee could be represented. Mr. Hall will accordingly arrange for a meeting of Committee A-4 during the annual meeting for the consideration of this question.

Voted, to accept this report.

(*b*) The Request of Committee D-10 on Shipping Containers in re Submission to the Society of Schedule for Nailing of Boxes: The committee has considered the correspondence in this matter referred to it by the Executive Committee. The proposed Schedule for Nailing appears to be simply an extension of what has already been included in the Tentative Specifications for Canned Foods Boxes (D 44 - 17 T) now published in the Proceedings. It is recommended that the Executive Committee authorize Committee D-10 to proceed with the preparation of this schedule for nailing and that we await the receipt of the next annual report of Committee D-10 in order to give the matter further consideration, if necessary, in the light of recommendation in that report. The Committee on Inter-Committee Relations recognizes that at least some of the work of Committee D-10 is on the border line of the field covered by the Society and it has kept in mind the decision of the Executive Committee in October, 1919, to have Committee D-10 proceed with its work along the lines originally indicated.

Voted, to leave this matter in the hands of the Secretary-Treasurer and the Chairman of the Committee on Inter-Committee Relations.

(*c*) Question of Specifying Patented Apparatus in A.S.T.M. Standards: The committee has considered the letter on this subject referred to it by the Executive Committee. The committees affected in this communication, D-1 on Preservative Coatings and D-2 on Lubricants, have been requested to inform the committee in detail as to the specifying of patented apparatus in certain of the standards in their charge. Complete information has not yet been received and the committee therefore reports progress.

Voted, to accept this report.

Reorganization of Committee E-1.—The report of the conference of members of Committee E-1 and the chairmen of standing committees on the reorganization of Committee E-1 on Methods of Testing was presented. The Regulations Governing Methods and Instruments of Testing, proposed in this report, follow:

PROPOSED REGULATIONS GOVERNING METHODS AND INSTRUMENTS OF TESTING.

1. *Methods of Testing.*—The responsibility for the preparation of methods of testing and the examination, design and recommendation of instruments, appliances and machines for testing is vested in the Standing Committees and each Standing Committee is expected to devote careful attention to the development, application and interpretation (in cooperation with other Standing Committees interested in similar subjects) of methods, instruments appliances and machines for testing the characteristics and properties of materials classified within its functions.

2. *Sub-Committees on Methods of Testing.*—It shall be the duty of each Standing Committee to designate one or more sub-committees from among its members to carry out the purposes of Section 1.

3. *Standing Committee on Methods of Testing.*—For administrative purposes there shall be established a general Standing Committee on methods, instruments, appliances and machines for testing. It shall be known as Committee E-1 on Methods of Testing and shall be responsible to the Executive Committee in an advisory capacity and for the performance of its functions as hereinafter described.

4. *Committee E-1 Members.*—Committee E-1 shall consist initially of seven members of the Society selected with special consideration of interest, experience and ability in methods, appliances and application of testing and the determination of engineering constants; and of knowledge of the fundamental principles of physics, chemistry and mathematics and of manufacturing processes and the limitations and uses of materials. The committee shall be selected by the Executive Committee of the Society in such a manner as to be representative of the broad activities of the Society; personal qualifications having precedence over group interest. Upon completion of its organization by the selection of a Chairman and a Secretary it shall have the right to nominate for the consideration of the Executive Committee members to fill vacancies; to recommend the enlargement of the committee—if in its judgment that is necessary—and the discontinuation and replacement of its members who fail from any cause to perform their duties; and to prescribe rules and regulations for the conduct of the committee work consistent with the provisions of the Regulations Governing Standing Committees.

5. *Associate Members.*—Each Standing Committee shall elect not over two members who shall serve as Associate Members of Committee E-1 during the consideration by Committee E-1 of any matters relating to the Standing Committee that they represent. The duties and privileges of Associate Members shall be as hereinafter set forth.

6. *Advisers.*—Committee E-1 shall have the privilege and it shall be its duty to invite especially qualified persons when desired to sit with it as advisers at such times as in its opinion matters requiring particular technical knowledge and information are under consideration, and Associate Members may invite members of their Standing Committees or Sub-Committees to attend meetings of Committee E-1 as advisers.

7. *Functions.*—Committee E-1 shall perform the following functions:

(*a*) To aid the Standing Committees in the preparation of standard methods and instruments of testing; in the correlation of similar methods in different committees; and in instituting cooperation between Standing Committees in matters relating to methods and instruments of testing, by the creation of sub-committees of Committee E-1 if that should seem advisable, especially on matters of common interest to a number of Standing Committees;

(*b*) To initiate, conduct and report research upon such engineering constants, methods and instruments for testing and fundamental problems of interest to the Society, as do not come within the functions of any other Standing Committee;

(*c*) To encourage, secure and promote, with the approval of the Executive Committee, cooperation in methods and instruments of testing between Standing Committees of this Society and the Committees of other Societies and Associations engaged upon similar work;

(*d*) To standardize the nomenclature and definitions used in or relating to testing methods or instruments;[1] and

(*e*) To perform such other functions as may advance, improve, standardize and unify the science of materials testing.

In discharging these functions, the Secretary of Committee E-1 shall notify the Chairman and Secretaries of all Standing Committees six weeks in advance of a regular meeting of Committee E-1 that matter intended for the consideration of Committee E-1 should be forwarded to him not later than two weeks in advance of said meeting. He shall further furnish to each member of Committee E-1, ten days in advance of said meeting in so far as possible, copies or a summary of reports, manuscripts, etc., intended for consideration at the meeting, and shall notify the Associate Members who, on account of the matters proposed for consideration, should be present.

8. *Obligations of Standing Committees.*—It shall be the duty of the Standing Committees:

(*a*) To cooperate with Committee E-1 in every way possible, furnishing Committee E-1 with such portions of the minutes of their meetings and such other information as relate to methods or instruments of testing which are under their consideration;

(*b*) To participate in the activities of Committee E-1 through the Associate Members, hereinbefore defined. It shall be the duty of the Associate Members to be present at the meetings of Committee E-1 at which communications affecting their work, either from their respective Standing Committees or other Standing Committees, are scheduled for consideration. During the discussion and final action on these communications, Associate Members shall have the full powers, privileges and responsibilities of Members; provided that Associate Members representing one Standing Committee shall have jointly but one vote; and

(*c*) To refer to Committee E-1 for its consideration and advice any proposed methods of testing or amendments thereof prior to their reference to the Society for adoption as standard.

Voted, to accept this report and direct the Committee on Inter-Committee Relations to proceed with the reorganization of Committee E-1 along the lines of the report.

The Secretary-Treasurer presented the following telegram from the Chairman and Secretary of Committee D-4:

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[1] The Executive Committee of the Society has authorized the formation of a Standing Committee on Nomenclature and Definitions, with which Committee E-1 should cooperate in the standardization of nomenclature and definitions used in or relating to testing methods or instruments.

"Committee D-4 unanimously urges that the proposed activities of Committee E-1 shall be defined so as specifically not to apply to tentative standards as may be proposed by any committee."

Voted, to make no change in the conference report.

The Secretary-Treasurer reported that a conference of representatives of Government departments and companies interested in the formation of a Committee on Screen Wire Cloth had been held on March 27 and that as a result of that conference the Secretary-Treasurer recommended that we proceed with the organization of such a committee.

Voted, to approve this recommendation.

The Secretary-Treasurer presented the following resolutions adopted by Committee E-6:

"*Voted* unanimously that Committee E-6 on Papers and Publications recommends to the Executive Committee that its membership be reorganized after the annual meeting upon the following basis:

"(1) That the Committee shall consist of nine members appointed by the Executive Committee, and ex officio the Secretary-Treasurer of the Society, who shall be Chairman of the Committee.

"(2) That the terms of office of the members shall be three years, so arranged that the terms of office of three members shall expire each year. (Thus in first appointing the reorganized committee, three members would have a term of office of one year, three of two years, and three of three years. Reappointees would have terms of three years)."

Voted, to approve the recommendations contained in this resolution.

The Secretary-Treasurer presented a communication from Committee A-1 on Steel requesting that the Executive Committee give further consideration to the revision of Section 19 of the Regulations Governing the Form of Standards relating to the expression of measurements in A.S.T.M. Standards in both English and metric units, as adopted at the last meeting and communicated by the Secretary-Treasurer to each committee of the Society.

Voted, that Committee E-5 on Standing Committees be requested to hold a hearing upon this subject and that the chairman of each standing committee be asked to invite the members of his committee to this hearing, with the statement that the presence of producers is especially desired.

The Secretary-Treasurer presented a communication from Mr. A. H. Blanchard, Chairman of Committee D-4 on Road Materials, requesting a decision of the Executive Committee on the practice of including in specifications methods of testing proposed or adopted in other societies or organizations and not yet considered or adopted by the A.S.T.M.

Voted, to refer this matter to the Committee on Inter-Committee Relations.

The Secretary-Treasurer presented a communication from Mr. W. H. Bassett, Chairman of Committee E-4 recommending (*a*) that Committee E-4 be changed from a Committee on Magnification Scales for Micrographs to a Committee on Metallography; and (*b*) that a standing committee of the Society be organized on the subject of Pyrometry.

Voted, to approve recommendation (*a*); and to direct the Secretary-Treasurer to investigate the situation with respect to recommendation (*b*) and to report if possible at the next meeting of the Executive Committee.

The Secretary-Treasurer presented a communication from Mr. D. K. Boyd, Chairman of Committee C-7, requesting that a conference committee on sand be created.

Voted, to refer this communication to the Committee on Inter-Committee Relations.

MISCELLANEOUS ITEMS.

The Secretary-Treasurer reported that at the direction of the President he had represented the Society at the annual meeting of the National Federation of Construction Industries held in Chicago March 24–25 and had presented upon their invitation, an address on the subject "Standardization and the American Society for Testing Materials."

The Secretary-Treasurer presented correspondence between the President and himself and Mr. H. L. Whittemore of the Bureau of Standards relative to Mr. Whittemore's suggestion that the A.S.T.M. should prepare and publish a list of testing laboratories in the country.

Voted, to confirm the decision of the President and Secretary-Treasurer that the Society could not undertake the publication of such a list.

The Secretary-Treasurer presented a request from the Technical Staff, U. S. Ordnance Department, that certain committees of the Society comment upon and present criticisms of specifications prepared by the Ordnance Department.

Voted, to refer this communication with power to the Secretary-Treasurer and the Chairman of the Committee on Inter-Society Relations.

The Secretary-Treasurer presented correspondence with Mr. C. W. Van Dyke of the Atlas Portland Cement Co., and Mr. A. V. Bleininger, Chairman of Committee C-3 on Brick, relating to a request of Mr. Van Dyke that the question of concrete brick be taken up by Committee C-3.

Voted, to direct the Secretary-Treasurer to inquire of Committee C-3 whether it would accept Mr. Van Dyke as a member of the committee, with the expectation that Mr. Van Dyke will then present his arguments direct to the committee.

REPORT OF COMMITTEE A-1

ON

STEEL.

During the past year Committee A-1 has held two meetings, one on October 3, 1919, and the second on March 5, 1920. A third meeting will be held prior to the presentation of this report to the Society, at which the report will be finally reviewed and several other important questions considered.

The Advisory Committee has held three meetings, at which matters concerning the general administrative affairs of the committee were considered.

The present membership of the committee is 123, of which 74 are classified as non-producers and 49 as producers.

Sub-Committees.—There have been no new sub-committees formed during the year, the total number being seventeen.

In its report last year the committee announced that it was endeavoring to organize a Sub-Committee on Deep Drawing Steel Stock. Considerable difficulty was experienced in arousing any particular interest in the prospective work of such a sub-committee, and Committee A-1 accordingly decided to discontinue for the present its efforts to organize the sub-committee.

As forecast in the report last year, Sub-Committee XV on Cold-Drawn Steel has been enlarged to include specifications for hot-rolled bars to be purchased to chemical composition. The new title of the sub-committee is Sub-Committee XV on Commercial Bar Steels, and the personnel of the sub-committee has been enlarged to make it thoroughly representative. The sub-committee has prepared Tentative Specifications for Commercial Bar Steels, to which reference is made later.

The committee also has under consideration the appointment of a separate sub-committee on specifications for finished rivets, in pursuance of a suggestion that the various requirements for rivets now appearing in several different specifications might properly be combined into a single specification.

RECOMMENDATIONS AFFECTING STANDARDS AND TENTATIVE STANDARDS.

The recommendations of the committee affecting standards and tentative standards are presented first in summarized form for convenient oversight. They are then referred to where necessary in greater detail, being grouped for convenience in the order of the respective sub-committees directly responsible for them.

I. Proposed Revisions in Standards.—The committee recommends that the revisions in the following standards, which are given in full in Appendix I to this report, be published as tentative for one year before referring them to letter ballot of the Society for adoption as standard:

1. For Quenched High-Carbon-Steel Splice Bars (A 49 – 15).
2. For Quenched Carbon-Steel Track Bolts (A 50 – 16).
3. For Quenched Alloy-Steel Track Bolts (A 51 – 16).
4. For Steel Screw Spikes (A 66 – 18).
5. For Structural Steel for Locomotives (A 10 – 16).
6. For Structural Steel for Cars (A 11 – 16).
7. Recommendations with respect to normalizing of cold-drawn rivet bars, affecting the following specifications:
    - (*a*) For Structural Steel for Bridges (A 7 – 16).
    - (*b*) For Structural Nickel Steel (A 8 – 16).
    - (*c*) For Structural Steel for Buildings (A 9 – 16).
    - (*d*) For Structural Steel for Cars (A 11 – 16).
    - (*e*) For Rivet Steel for Ships (A 13 – 14).
    - (*f*) For Boiler Rivet Steel (A 31 – 14).
8. For Lap-Welded and Seamless Steel Boiler Tubes for Locomotives (A 28 – 18).
9. For Welded Steel Pipe (A 53 – 18).

    As explained later under the heading "Steel Tubing and Pipe," the revisions in these specifications are sufficiently extensive to have warranted rewriting the specifications, and the proposed revised specifications will be found appended hereto.[1]
10. For Automobile Carbon and Alloy Steels (A 29 – 18).

II. Proposed Revisions in Tentative Standards.—The committee recommends that the revisions in the following tentative specifications, which appear in Appendix I to this report, be approved, and that the specifications as thus revised be continued as tentative for another year:

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[1] See p. 487.—ED.

11. For Steel Tie Plates (A 67 – 18 T).
12. For Low-Carbon-Steel Track Bolts (A 76 – 18 T).
13. For Steel Plates for Forge Welding (A 78 – 19 T).
14. For Carbon Tool Steel (A 71 – 17 T).
15. For Electric Cast Steel Anchor Chain (A 77 – 18 T).

The committee also recommends that the Tentative Specifications for Boiler and Firebox Steel for Stationary Service (A 70 – 18 T) be continued as tentative without revision.

III. Proposed New Tentative Standard.—The committee recommends that the following new specification, which is appended to this report,[1] be accepted for publication as tentative:

16. For Commercial Bar Steels.

The above recommendations have been referred to letter ballot vote of the committee, which consists of 123 members: 99 ballots have been cast, 24 members having refrained from voting. The analysis of the vote of the committee is given in the following table:

Items.	Affirmative.	Negative.	Not Voting.[a]
I. PROPOSED REVISIONS IN STANDARDS.			
1. For Quenched High-Carbon-Steel Splice Bars (A 49 – 15)	51	2	46
2. For Quenched Carbon-Steel Track Bolts (A 50 – 16)	49	1	49
3. For Quenched Alloy-Steel Track Bolts (A 51 – 16)	49	1	49
4. For Steel Screw Spikes (A 66 – 18)	48	2	49
5. For Structural Steel for Locomotives (A 10 – 16)	62	1	36
6. For Structural Steel for Cars (A 11 – 16)	62	1	36
7. Recommendation with respect to normalizing of cold-drawn rivet bars:			
(*a*) For Structural Steel for Bridges (A 7 – 16)	62	1	36
(*b*) For Structural Nickel Steel (A 8 – 16)	61	1	37
(*c*) For Structural Steel for Buildings (A 9 – 16)	61	1	37
(*d*) For Structural Steel for Cars (A 11 – 16)	62	1	36
(*e*) For Rivet Steel for Ships (A 13 – 14)	57	3	39
(*f*) For Boiler Rivet Steel (A 31 – 14)	55	7	37
8. For Lap-Welded and Seamless Steel Boiler Tubes for Locomotives (A 28 – 18)	53	0	46
9. For Welded Steel Pipe (A 53 – 18)	52	2	45
10. For Automobile Carbon and Alloy Steels (A 29 – 18)	45	0	54
II. PROPOSED REVISIONS IN TENTATIVE STANDARDS.			
11. For Steel Tie Plates (A 67 – 18 T)	46	4	49
12. For Low-Carbon-Steel Track Bolts (A 76 – 18 T)	49	1	49
13. For Steel Plates for Forge Welding (A 78 – 19 T)	54	1	44
14. For Carbon Tool Steel (A 71 – 17 T)	54	4	41
15. For Electric Cast Steel Anchor Chain (A 77 – 18 T)	46	0	53
III. PROPOSED NEW TENTATIVE STANDARD.			
16. For Commercial Bar Steels	59	6	34

Total number of ballots cast	99
Number of members who failed to vote	24
Total membership	123

[a] In this column is recorded the number of votes cast as "Not Voting" on the various items.

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[1] See p. 518.—Ed.

In the following the committee presents the foregoing recommendations in detail where necessary, as well as other features of its work, grouped for convenience in the order of the respective sub-committees responsible for them.

STEEL RAILS AND ACCESSORIES (SUB-COMMITTEE I).

Revision in Track Bolt Specifications.—Last year the committee announced[1] its intention of proposing a revision in the workmanship requirements of the Tentative Specifications for Low-Carbon-Steel Track Bolts (A 76 - 18 T), and the revision is given in Appendix I. This revision is now proposed also for the Standard Specifications for Quenched Carbon-Steel Track Bolts (A 50 - 16) and for Quenched Alloy-Steel Track Bolts (A 51 - 16) to be published as tentative for one year.

Cooperation with the Track Committee of the American Railway Engineering Association.—The committee has been cooperating through Sub-Committee I with the Track Committee of the American Railway Engineering Association to the extent of presenting criticisms and recommendations concerning the specifications of that Association for track spikes, screw spikes and tie plates. This cooperative work has led the committee to propose a minor revision in the Standard Specifications for Steel Screw Spikes (A 66 - 18) which will bring the A.S.T.M. specifications into conformity with those of the A.R.E.A. (see Appendix I). The committee understands that the A.R.E.A. Track Committee is recommending for adoption in their Association, Specifications for Screw Spikes and Track Spikes which are practically in accord with the A.S.T.M. specifications for these products.

The committee has not been able to reach an agreement with the Committee of the A.R.E.A. on Specifications for Tie Plates. In fact, Sub-Committee I itself has had considerable difficulty in agreeing on Specifications for Tie Plates, and in view of this they have hesitated in commenting upon the specifications of the A.R.E.A. The Track Committee of the latter Association has furnished the members of Sub-Committee I with copies of the Tie Plate Specifications that they are recommending for adoption. Sub-Committee I will study these specifications during the coming year.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XIX, Part I, p. 171 (1919).

A revision in the Tentative Specifications for Steel Tie Plates (A 67 – 18 T) is proposed in Appendix I to this report, by which the permissible variation in rolled width of plates with shoulders perpendicular to the direction of rolling is increased from $\frac{1}{8}$ to $\frac{3}{16}$ in. This increase in tolerance has been found to be necessary owing to the fact that it is impossible to maintain the width within closer limits on the large number of plates of intricate design that are now being manufactured.

Revision in Standard Specifications for Quenched High-Carbon-Steel Splice Bars (A 49 – 15).—A revision in these specifications is proposed in Appendix I by which the requirements for retest are modified to conform with similar requirements in the Specifications for Track Bolts (A 50 – 16 and A 51 – 16).

Rail Specifications.—The committee has marked time in the consideration of revisions in A.S.T.M. Specifications for Carbon-Steel Rails (A 1 – 14), in view of the fact that the Rail Committee of the American Railway Engineering Association is about to adopt a revised rail specification, and the committee wishes to make every effort to meet the recommendations of that Association. The formal cooperative relations which it was hoped to establish with the A.R.E.A. Rail Committee were not found possible and Committee A-1 accordingly will take up during the coming year the revision of the A.S.T.M. specifications. Sub-Committee I has already held one meeting at which revisions in the specifications were considered in detail, and the committee accordingly reports progress on this question.

SPECIFICATIONS FOR STRUCTURAL STEEL (SUB-COMMITTEE II).

Revisions in Tentative Specifications for Plates for Forge Welding (A 78 – 19 T).—During the year the committee has received several criticisms of the Tentative Specifications for Steel Plates for Forge Welding (A 78 – 19 T), of which the most important was one from Mr. A. W. Gibbs, chairman of the Tank Car Committee of the American Railroad Association. Mr. Gibbs submitted the results of many tests which indicated that possibly the minimum tensile strength limits in the specifications of 48,000 lb. per sq. in. for plates $\frac{3}{4}$ in. or under in thickness, and 45,000 lb. per sq. in. for plates over $\frac{3}{4}$ in. in thickness were lower than necessary. Mr. Gibbs further emphasized the viewpoint of the Tank Car Committee that while tensile strength is less important than chemical requirements (because deficiency in tensile strength can be compensated for by increasing the thickness of plate), the designs of tanks must be based on the lowest tensile strength limit allowed in the specifications; so that the practical effect is to carry around in most cases considerable unnecessary weight, for the experience has been that the tensile strength of the weakest sheets will in most cases be materially above the lower limit of the specifications.

Objections were also received by the committee from the welding interests to the minimum manganese requirement of 0.30 per cent, the claim being made that it should not be less than 0.40 per cent.

After careful consideration the committee has determined to recommend revisions in these specifications, which appear in Appendix I to this report, by which the minimum tensile strength for all plates is increased to 50,000 lb. per sq. in. and the carbon content for plates over $\frac{3}{4}$ in. in thickness raised to not over 0.20 per cent. The minimum manganese limit has also been raised to 0.40 per cent.

The committee recommends that these specifications as revised be continued as tentative.

Specifications for Structural Steel for Locomotives (*A 10 – 16*) *and Structural Steel for Cars* (*A 11 – 16*).—The committee proposes in Appendix I to this report a revision in each of these specifications by which plates $\frac{3}{16}$ in. or under in thickness shall not be subject to tension test.

NORMALIZING OF COLD-DRAWN RIVET BARS (SUB-COMMITTEES II, III AND XI).

During the year the attention of Committee A-1 was called by the Boiler Code Committee of the American Society of Mechanical Engineers to inquiries that had reached them concerning the acceptability of rivets manufactured from bars cold-drawn to finished size. The physical requirements for rivets specified in the A.S.T.M. specifications—and also in those of the American Railroad Association—are based upon hot-rolled bars. This question was referred by the committee to the three sub-committees in charge of specifications for rivets for various uses, namely, Sub-Committees II, III and XI. Upon the joint recommendation of these three sub-committees the committee is proposing a revision in the following standard specifications providing that tension and bend test specimens for rivet bars which have been cold-drawn shall be normalized before testing:

For Structural Steel for Bridges (A 7 – 16).
For Structural Nickel Steel (A 8 – 16).
For Structural Steel for Buildings (A 9 – 16).
For Structural Steel for Cars (A 11 – 16).
For Rivet Steel for Ships (A 13 – 14).
For Boiler Rivet Steel (A 31 – 14).

It is recommended that this revision be published as tentative for one year.

STEEL WHEELS AND TIRES (SUB-COMMITTEE VII).

The committee has recommended to the Executive Committee of the Society that a Joint Committee be formed of representatives of the A.S.T.M. and the Mechanical Section of the American Railroad Association to harmonize certain differences in the Specifications for Steel Wheels and Tires of the two organizations. This suggestion is now under consideration.

STEEL CASTINGS FOR RAILROADS.

A most important development in the study of Specifications for Steel Castings for Railroads has been the formation in January, 1920, of a Joint Committee on Steel Castings for Railroads consisting of representatives of the American Society for Testing Materials, the Mechanical Section of the American Railroad Association, and the U. S. Railroad Administration. This joint committee was organized by the executive boards of the three organizations, in pursuance of an agreement to work together wherever feasible in the consideration of problems of mutual interest.

The personnel of the Joint Committee is as follows:

Representing American Society for Testing Materials:

American Locomotive Works.
American Steel Foundries.
Baldwin Locomotive Works.
Birdsboro Steel Foundry and Machine Co.
Commonwealth Steel Co.
Eagan-Rogers Steel and Iron Co.
National Malleable Castings Co.
Norfolk & Western Railway.
Penn Seaboard Steel Corporation.
Philadelphia & Reading Railroad.
Pratt & Letchworth Co.
Pressed Steel Car Co.
Standard Steel Works Co.
Union Pacific Railroad.
Union Steel Castings Co.

Representing American Railroad Association, Mechanical Section:

Ayers, A. R.
Burnham, H. G.
Downing, I. S.
Fetters, A. H.
Johnson, G. T.
Kleine, R. L.
MacFarland, H. B.
Onderdonk, J. R.
Pilcher, J. A.
Waring, F. M.
Zeleny, F.

Representing U. S. Railroad Administration:

Smith, H. E.

The representatives of the Society are all members of Committee A-1 and they form in effect a special sub-committee of that committee on railroad castings. The chairman of the Joint Committee is Mr. F. M. Waring, and Mr. J. C. Davis of the American Steel Foundries has been elected chairman of the A.S.T.M. representatives.

The Joint Committee has held two meetings at which specifications for railroad castings have been carefully considered. When specifications are finally prepared and adopted by the Joint Committee, they will be submitted to Committee A-1 on Steel and to the appropriate committee of the Mechanical Section, A.R.A., for independent action. Committee A-1 hopes that it will be possible to submit specifications to the Society at the annual meeting in 1921.

STEEL TUBING AND PIPE (SUB-COMMITTEE IX).

Specifications for Lap-Welded and Seamless Steel Boiler Tubes for Locomotives (*A 28 - 18*).—The committee proposes several relatively minor changes in these specifications, as listed in Appendix I to this report. The principal revision is to make Section 14 (*a*) of the specifications agree with the corresponding section in Standard Specifications for Lap-Welded and Seamless Steel and Wrought-Iron Boiler Tubes for Stationary Service (A 52 - 18).

Specifications for Welded Steel Pipe (A 53 - 18).—As announced in the report of the committee for last year, Committee A-1 has had under consideration in cooperation with Committee A-2 on Wrought Iron a revision of the present Specifications for Welded Steel Pipe (A 53 - 18) and for Welded Wrought-Iron Pipe (A 72 - 18). The two committees have agreed upon an extension of the tables for hydrostatic pressures and standard weights of welded pipe to include pipe up to and including 12 in. in diameter. Committee A-1 also proposes certain other modifications in Specifications A 53 - 18, of which the most important is the addition of a requirement for open-hearth steel pipe. Sections 2 (*a*), 2 (*b*) and 17 have been omitted, Section 1 modified, and Sections 15 (*a*) and (*b*) combined. The specifications in their proposed revised form are appended hereto[1] with the recommendation that they be accepted for publication as tentative, to supersede the present specifications when adopted as standard.

In the consideration of the revisions in these specifications, Committee A-1 has kept and will continue to keep in touch with the Boiler Code Committee of the American Society of Mechanical Engineers.

AUTOMOBILE STEELS (SUB-COMMITTEE X).

The committee recommends that the revision of the Standard Specifications for Automobile Carbon and Alloy Steels (A 29 - 18), included in Appendix I to this report, be published as tentative for one year. This revision was included as an appendix to the report of the committee last year, but it had been proposed too late to enable the committee to conduct the necessary letter ballot vote.

This revision was arrived at by Sub-Committee X in cooperation with a committee of the Society of Automotive

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[1] See p. 487.—ED.

Engineers and will bring the A.S.T.M. specifications and those of the S.A.E. into exact harmony.

LADLE TEST INGOT INVESTIGATION (SUB-COMMITTEE XII).

The committee reports progress in the investigation of Sub-Committee XII on Ladle Test Ingots. The sub-committee is actively engaged in collecting materials to continue the investigation. One of the studies contemplated during the coming year is the influence of aluminum in test ingots.

TOOL STEEL (SUB-COMMITTEE XIV).

The committee recommends certain revision in the Tentative Specifications for Carbon Tool Steel (A 71 - 17 T) which are given in full in Appendix I to this report. The principal change is the omission of the ten grades of carbon tool steel, with carbon varying 0.15 per cent between certain fixed limits, and the substitution therefor of a provision that the percentage of carbon may vary by ranges of 0.10 per cent, with rejection limits plus or minus 0.025 per cent. By this provision tool steel may be ordered, for example, with a carbon range of 0.60 to 0.70 per cent, with rejection limits of 0.575 and 0.725 per cent, which would not be possible under the present specifications.

The committee is not yet prepared to recommend these specifications for adoption as standard and therefore asks that they be continued as tentative in their proposed revised form.

COMMERCIAL BAR STEELS (SUB-COMMITTEE XV).

As previously mentioned, Sub-Committee XV has been enlarged from a committee on cold-drawn steel to include also hot-rolled bars to be purchased to chemical composition. The sub-committee has accordingly prepared Specifications for Commercial Bar Steels, which have been adopted by the committee and are recommended for publication by the Society as tentative.[1] The specifications cover ordinary commercial carbon bar steels of grades considered to be in common use. Both open-hearth and Bessemer steels are specified, and bars may be hot-rolled or cold-finished as specified. The sections covered are rounds, squares and hexagons of all sizes, and flats not over 6 in. wide. The principal requirements of the specifications are chemical properties and permissible variations in dimensions. In the preparation of these specifications the sub-committee has consulted various authorities, such as Manufacturers' Standard Specifications for Blooms, Billets and Slabs for Forging Purposes, 1912; Manufacturers' Standard Specifications for Allowable Variations in Size of Hot-Rolled Bars, 1910; British Standard No. 32 for Steel Bars; and several A.S.T.M. specifications.

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[1] See p. 518.—ED.

The committee has approved the recommendation of Sub-Committee XV that alloy steels should not be included in a commercial bar specification.

CAST STEEL CHAIN (SUB-COMMITTEE XVI).

The committee recommends that the revisions in the Tentative Specifications for Electric Cast Steel Anchor Chain (A 77 – 18 T) proposed in Appendix I to this report be approved and the specifications continued as tentative. It is felt that the revisions are self-explanatory and require no comment here.

Sub-Committee XVI has had under consideration the question of including chemical limits for the steels covered in these specifications. In view of statements made by users of the chain, the sub-committee has concluded that in the present state of the art it is unnecessary to include chemical limits; and Committee A-1 has approved the recommendation of the sub-committee to that effect.

LITERARY FORM (SUB-COMMITTEE XVII).

The Sub-Committee on Literary Form, in addition to taking care of a number of editorial questions that have arisen in connection with the specifications submitted with this report has proposed the following recommendations for the consistent use of the terms "class," "type" and "grade" in the various steel specifications:

Class.—To be used to designate division of products by size, shape or finish, or by service for which products are used; also to express distinctions of quality of the same types of steel.

Type.—To be used to designate kinds of steel, that is, whether plain carbon steel, or the various divisions of alloy steels.

Grade.—To be used to designate divisions of any type or class of steel by carbon content or physical properties.

These recommendations are in accordance with present usage of these terms, and have been adopted by Committee A-1. These terms appear in 19 specifications in charge of the committee, in eleven of which the usage is consistent with the above definitions. Of the remaining eight specifications, five (A 14 – 16, A 68 – 18, A 58 – 16, A 59 – 16 and A 60 – 16) use the term "class" where "grade" should be used; and three (A 30 – 18, A 70 – 18 T and A 71 – 17 T[1]) use the term "grade" where "class" should be used. The committee recommends that these specifications be modified to make them consistent with other specifications. This recommendation concerns only the form of the specifications as distinguished from substance, and accordingly if the change is approved it will not be necessary to change the date of last revision.

BEND TEST REQUIREMENTS (SPECIAL SUB-COMMITTEE).

In 1917 the committee organized a special sub-committee to make an analysis of the various bend test requirements in the specifications in the charge of Committee A-1, with a view of harmonizing these requirements if it appeared necessary. The sub-committee planned a series of tension and bend tests on the various grades of steel covered in the specifications, but the work was seriously delayed on account of the war. During the past year the sub-committee has completed these tests and prepared also an analysis of the bend test requirements in the A.S.T.M. specifications. As a result of this anslysis it appears that, viewed from the standpoint of practical application, the bend test requirements in the various steel specifications are not inconsistent. The sub-committee has recommended that no general changes be made in the bend test requirements, but that in some places it is desirable to harmonize the wording of the various specifications in which bend tests are specified. This recommendation has been approved by the committee.

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[1] These specifications are the Tentative Specifications for Carbon Tool Steel, and the proposed change has been embodied in the revision proposed in these specifications. (See Appendix I, p. 136.)

The sub-committee has accordingly under consideration, in conjunction with the Sub-Committee on Literary Form, certain minor recommendations with respect to the wording of the bend test clauses, which will be submitted during the coming year to the various sub-committees for their consideration.

SPECIFICATIONS FOR ALUMINUM SHOT FOR USE IN THE MANUFACTURE OF IRON AND STEEL.

Reference was made in the report last year to a suggestion of one of the members of the Society that specifications be prepared for aluminum for use in the manufacture of steel. Committee A-1 referred this suggestion to Committee B-2 and offered to appoint a committee of steel manufacturers to cooperate with the appropriate sub-committee of Committee B-2, should the latter committee decide to prepare such specifications. The suggestion met with the approval of Committee B-2 and accordingly a special committee was appointed to cooperate in the preparation of the specifications, consisting of Mr. F. N. Speller, chairman, and Messrs. G. W. Sargent, J. L. Uhler, D. M. Buck and J. A. Aupperle. Messrs. Buck and Aupperle, not being members of Committee A-1, have served as Advisory Members, and the committee accordingly wishes to acknowledge with appreciation the assistance that they have rendered.

The committee has been of considerable assistance to the sub-committee of Committee B-2 in the preparation of Specifications for Aluminum for Use in the Manufacture of Iron and Steel, which are being proposed by Committee B-2 at this annual meeting for publication as tentative.

PHOSPHORUS AND SULFUR REQUIREMENTS IN A.S.T.M. STEEL SPECIFICATIONS.

In connection with the presentation of the report of Committee A-1 last year it was stated[1] that the committee had under consideration "the creation of a special committee to make a study of the influence of phosphorus and sulfur in steel and to determine whether the phosphorus and sulfur limits in the

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XIX, Part I, p. 18 (1919).

A.S.T.M. steel specifications are proper ones." In this study it was hoped to secure the cooperation of the U. S. Railroad Administration and the U. S. Bureau of Standards.

Committee A-1 appointed a committee consisting of the chairmen of its various sub-committees to confer with the Bureau of Standards and the Railroad Administration on the matter of organizing a joint committee to conduct an investigation upon this subject and to prepare a provisional program. Two conferences were held, one in September and the other in October of 1919, and a very complete report was presented to Committee A-1 at its meeting on October 3, 1919. The report included a provisional program of tests to determine the effect of phosphorus and sulfur in the six groups of steels comprising the range of specifications for which Committee A-1 is responsible; and recommended the organization of a joint committee to conduct an investigation.

Committee A-1 accordingly recommended to the Executive Committee of the Society that it take steps to organize a suitable committee, and on November 29, 1919, the Joint Committee on Investigation of Phosphorus and Sulfur in Steel was formally organized under the chairmanship of Dr. George K. Burgess of the Bureau of Standards. The organizations at present represented on the Joint Committee, with the names of their representatives, are as follows:

U. S. Bureau of Standards	Geo. K. Burgess H. L. Whittemore
American Railroad Association[1]	F. M. Waring H. B. MacFarland
American Society for Testing Materials	R. W. Hunt & Co. T. D. Lynch
Association of American Steel Manufacturers	E. F. Kenney J. J. Shuman
U. S. War Department	F. C. Langenberg
U. S. Navy Department	D. J. McAdam, Jr.
Society of Automotive Engineers	F. P. Gilligan
Society of Naval Architects and Marine Engineers	F. W. Wood

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[1] The membership of the U. S. Railroad Administration on the Joint Committee was taken over by the American Railroad Association upon the dissolution of the Railroad Administration.

Steel Founders' Society of America.....J. E. McCauley
Engineering Division, National Research
Council.........................J. H. Hall

The Secretary of the Joint Committee is the Secretary-Treasurer of the Society.

The Joint Committee has adopted the provisional program of tests previously referred to as a basis upon which to plan the comprehensive investigation in mind. Since it is believed that the members of the Society will be greatly interested in this program of tests, it is given in full in Appendix II to this report.

The following is quoted from statements for publicity of its activities prepared by the Joint Committee:

> "The tests are divided into two series: Series A includes six groups of material each typical of their class as to carbon and manganese, and with phosphorous and sulfur ranging from 0.02 to 0.08 per cent, it being understood that when studying the effect of sulfur, the phosphorus content is to be as nearly constant as possible and equal to the usual value for that group of material, and vice versa. Also, the sulfur in the steels of this series is to be 'residual sulfur,' that is, sulfur present in the steel through fuel or from pig iron or scrap.
>
> "Series B is designed to provide for higher sulfurs than can, generally speaking, be obtained as 'residual sulfur.' In this series, therefore, sulfur may be added during the later stages of manufacture. Any heats originally prepared for Series A which run too high in phosphorus or sulfur may be diverted to Series B.
>
> "The tests planned in Series A are obviously of more immediate economic importance dealing as they do with the usual ranges of sulfur and phosphorus, extending in each instance up to limits which are not likely to be exceeded in ordinary practice. The tests under Series B, however, are necessary in order to carry the tests, if possible, to a point where the material will unquestionably fail from the effect of higher impurities.
>
> "The Joint Committee considers that the first essential is to secure all possible existing data afforded by service of material. As to the kinds of tests to determine the effect of phosphorus and sulfur, the committee believes that laboratory, fabricating and service tests are essential. Laboratory tests unsupported by fabricating and service tests would not, it is believed, be conclusive.
>
> "The Joint Committee has divided its work into three major parts, as indicated by the following committees:
>
> Committee on Statistics: H. L. Whittemore, Chairman.
> Committee on Manufacture: G. K. Burgess, Chairman.
> Committee on Tests: F. C. Langenberg, Chairman.

"The Committee on Statistics will visit steel manufacturers and users, including among the latter both large and smaller railroad lines, to obtain information on material high in phosphorus and sulfur which has either failed in service or which has proven satisfactory. A complete record of such material will be obtained, if possible. Material worthy of study will be secured and placed at the disposal of the Committee on Tests. The committee will also prepare a bibliography of this subject for the use of the Joint Committee.

"The Committee on Manufacture will supervise the manufacture of all steels to be prepared under the program of tests adopted by the Joint Committee and revised from time to time. Members of the committee or their representatives will be present at all essential operations in the manufacture of steels to be tested.

"The Committee on Tests will receive all material as submitted to it by the other two committees and make suitable tests upon it in accordance with the Program of Tests outlined by the Joint Committee. It is planned that Standard A.S.T.M. Methods of Testing will be followed, subject to such modifications as may seem desirable. Special proof and service tests, including impact and endurance tests, will be made where possible. The committee will also endeavor to determine the amount and types of gases present in steels under investigation. At present it is planned that material will be tested in the laboratories at Watertown Arsenal, Watertown, Mass., The Naval Experiment Station, Annapolis, Md., and the Bureau of Standards, Washington, D. C. The various tests will be carefully supervised by the committee. Routine tests will be witnessed by at least one member of the committee, and proof, service and other special tests, by at least two members of the committee.

"The Joint Committee has determined to study first the effect of sulfur, inasmuch as that presents the most urgent problem economically. The Committee on Manufacture has supervised the manufacture of thirteen heats of rivet steel of sulfur content ranging from 0.03 to 0.08 per cent, the phosphorus content remaining normal. The committee inspected all stages of the process of manufacture from the open hearth to the rolling of the rivet rounds. The manufacturers kindly furnished the records of the open-hearth charges as well as rolling temperatures.

"It was the original intention of the Committee on Manufacture to obtain material from ingots which had not been allowed to go cold. The manufacturers, however, offered also a series of cold ingots of 0.03, 0.04, 0.05 and 0.06 per cent sulfur, which the committee accepted as it thought that this might be a means of furnishing additional information.

"One ingot weighing about 6400 lb. from each heat was rolled into billets (4 by 4 in. by 4 ft.). In order to eliminate any variable that might be introduced by piping or segregation, it was decided to discard 40 per cent of the steel from the top of each ingot. The next six billets after the top discard, numbered one to six in sequence, were taken for the purposes of this investigation and each billet was properly stamped with the heat and billet number. Billets 1, 2, 3 and 4 from each ingot were rolled into

$\frac{63}{64}$-in. rounds, each billet yielding 8 bars 9 ft. 8 in. in length; billets 5 and 6 from each of the ingots were held in reserve.

"Approximately one-half of the material was shipped to Watertown Arsenal, the U. S. Naval Experiment Station at Annapolis, and the Bureau of Standards, for the various mechanical tests. The remainder was made into rivets at the Pennsylvania Railroad Co., shops at Altoona, and the Champion Rivet Co., Cleveland, Ohio. The rivets were made into two types of head, namely, cone and button, and $2\frac{3}{4}$, $3\frac{1}{2}$, and 6-in. lengths. Temperature readings on the various bars were taken with an optical pyrometer.

"After heading, each individual rivet was properly stamped on the head with the heat letter, billet number and the official committee stamp; the rivets were afterwards shipped to the three above mentioned testing stations where they are to be subject to test.

"The greatest interest has been shown in this investigation. The manufacturers in particular have given it their hearty support, having agreed to furnish the material necessary to conduct the investigation. The Government Departments have offered the facilities of their laboratories for conducting tests, as have also the manufacturers and several of the large railroads who have been approached. The various interests represented on the Joint Committee have agreed to assume such expenses of the investigation as come up naturally in the course of their participation therein, so that up to the present the Joint Committee has not found it necessary to raise a general fund for this purpose; nor is there any reason to believe that, for the present at least, the raising of such a fund would be necessary. Financial matters have been delegated to a Committee on Finance."

Phosphorus and Sulfur Note in A.S.T.M. Specifications.—It will be recalled that at the last annual meeting, Committee A-1 recommended that the note which had been added to 43 specifications by action of the Society in 1918, raising the rejection limits for sulfur in all steels and for phosphorus in acid steels 0.01 per cent above the values given in the specifications, was removed from 29 of those specifications, effective July 1, 1919; and that with respect to the remaining 14 specifications, consideration of the removal of the note was deferred until the annual meeting in 1920. The specifications on which the note now appears are as follows:

Standard Specifications for:

- Carbon-Steel Rails (A 1 – 14);
- Low-Carbon-Steel Splice Bars (A 3 – 14);
- Structural Steel for Buildings (A 9 – 16);

Structural Steel for Locomotives (A 10 – 16);
Structural Steel for Cars (A 11 – 16);
Structural Steel for Ships (A 12 – 16);
Rivet Steel for Ships (A 13 – 14);
Billet-Steel Concrete Reinforcement Bars (A 15 – 14);
Steel Castings (A 27 – 16);
Lap-Welded and Seamless Steel Boiler Tubes for Locomotives (A 28 – 18);
Lap-Welded and Seamless Steel and Wrought-Iron Boiler Tubes for Stationary Service (A 52 – 18);
Iron and Steel Chain (A 56 – 18);

Tentative Specifications for:

Steel Tie Plates (A 67 – 18 T);
Low-Carbon-Steel Track Bolts (A 76 – 18 T).

At its meeting to be held prior to the presentation of this report, Committee A-1 will consider what recommendations it desires to make to the Society with respect to the continuation or removal of the note in question; and will present its recommendations concurrently with this report.[1]

SUBMISSION OF STANDARDS FOR THE APPROVAL OF THE AMERICAN ENGINEERING STANDARDS COMMITTEE.

At the request of the Executive Committee of the Society, the committe has reviewed the standards for which it is responsible—50 in number—for the purpose of recommending to the Executive Committee those specifications which in its opinion should be submitted to the American Engineering Standards Committee for approval as "American Standard." The Advisory Committee of Committee A-1 has reviewed these specifications and will recommend the following specifications for submission:

For Carbon-Steel and Alloy-Steel Blooms, Billets and Slabs for Forgings (A 17 – 18);
For Carbon-Steel and Alloy-Steel Forgings (A 18 – 18);
For Quenched-and-Tempered Carbon-Steel Axles, Shafts, and Other Forgings for Locomotives and Cars (A 19 – 18);

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[1] For the recommendations of Committee A-1 made to the Society with regard to the phosphorus and sulfur note, and the action of the Society thereon, see Summary of the Proceedings, pages 15–16.—ED.

For Quenched-and-Tempered Alloy-Steel Axles, Shafts, and Other Forgings for Locomotives and Cars (A 63 – 18);
For Carbon-Steel Forgings for Locomotives (A 20 – 16);
For Carbon-Steel Car and Tender Axles (A 21 – 18);
For Cold-Rolled Steel Axles (A 22 – 16);
For Cold-Drawn Bessemer Steel Automatic Screw Stock (A 32 – 14);
For Cold-Drawn Open-hearth Steel Automatic Screw Stock (A 54 – 15).

Suitable statements giving the history of the preparation and use of these specifications will be prepared for the information of the Standards Committee.

A number of other specifications are under consideration by the Advisory Committee in this connection and will be acted upon in the near future.

This report has been submitted to letter ballot of the committee, which consists of 123 members, of whom 99 have voted affirmatively, 5 negatively, and 19 have refrained from voting.

Respectfully submitted on behalf of the committee,

F. M. WARING,
Chairman.

C. L. WARWICK,
Secretary.

EDITORIAL NOTE.

The proposed revisions in the ten standard specifications listed in this report as items 1 to 10 on page 114, were accepted ~~for publi~~cation as tentative and appear on pages 809–812.

The proposed revisions in the five tentative standards listed in this report as items 11 to 15 on page 115, were accepted. The tentative standards as thus revised appear on pages 493 and 502–517.

The proposed Tentative Specifications for Commercial Bar Steels were accepted for publication as tentative and appear on page 518.

For the recommendations of Committee A-1 made to the Society with regard to the phosphorus and sulfur note and the action of the Society thereon, see Summary of the Proceedings, pages 15–16.

APPENDIX I.

PROPOSED REVISIONS IN STANDARDS AND TENTATIVE STANDARDS FOR STEEL.

In this appendix are given proposed revisions in certain standard and tentative specifications, which for convenience are numbered from 1 to 21 to correspond to the report of the committee. In connection with each title is given the reference to the publication in which the specification appears in its present form.

PROPOSED REVISIONS IN STANDARDS.

NO. 1.—STANDARD SPECIFICATIONS FOR QUENCHED HIGH-CARBON-STEEL SPLICE BARS: A 49 – 15.[1]

Section 11.—Change to read as follows by the addition of the italicized words and the omission of the words in brackets:

"If the results of the physical tests of any test lot do not conform to the requirements specified, [the manufacturer may re-treat such lot one or more times and retests shall be made as specified in Section 10.] *two additional tension and two additional bend tests shall be made from such lot, all of which shall conform to the requirements specified.*"

NO. 2.—STANDARD SPECIFICATIONS FOR QUENCHED CARBON-STEEL TRACK BOLTS: A 50 – 16.[1]

Section 11.—Change to read as follows:

"The bolts and nuts shall conform to the dimensions specified by the purchaser. They shall be neatly formed and free from fins or nicking. The head of the bolt shall be concentric with and firmly joined to the shank, with the underside at right angles to the axis of the bolt. The threads shall be sharp and true to gage and of the design specified by the purchaser. The nuts shall have a hand free fit on the bolt from two to six turns, and wrench tight the balance of the screw length without distorting the threads or twisting the shank. They shall be screwed on the bolts before packing, a sufficient number of turns to hold them in place until used. A variation of $\frac{1}{32}$ in. under and $\frac{1}{64}$ in. over the specified diameter of the shank of the bolt will be permitted. The diameter of rolled thread shall not exceed the diameter of the shank more than $\frac{1}{16}$

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[1] 1918 Book of A.S.T.M. Standards.

in. for bolts $\frac{7}{8}$ in. in diameter and under, nor more than $\frac{3}{32}$ in. for bolts 1 in. in diameter and over. The outside diameter of the finished rolled thread shall not exceed the diameter of the shank of a cut thread bolt of corresponding size. The length of the bolt under the head shall not vary more than $\frac{1}{8}$ in. from that specified. A variation in the dimensions of the elliptical shoulders under the head of $\frac{1}{32}$ in. and a taper of the shoulder of $\frac{1}{32}$ in. will be permitted."

NO. 3.—STANDARD SPECIFICATIONS FOR QUENCHED ALLOY-STEEL TRACK BOLTS: A 51 – 16.[1]

Section 11.—Make the same change as in Section 11 of Specifications A 50 – 16 above.

NO. 4.—STANDARD SPECIFICATIONS FOR STEEL SCREW SPIKES: A 66 – 18.[1]

Section 7.—Change the fifth sentence to read as follows by the omission of the words in brackets:

"A variation of $\frac{1}{32}$ in. over [and under] the specified diameter of the unthreaded portion of the body of the spike will be permitted."

NO. 5.—STANDARD SPECIFICATIONS FOR STRUCTURAL STEEL FOR LOCOMOTIVES: A 10 – 16.[1]

Section 6.—Add a sentence to read as follows:

"Plates $\frac{3}{16}$ in. or under in thickness shall not be subject to tension tests."

NO. 6.—STANDARD SPECIFICATIONS FOR STRUCTURAL STEEL FOR CARS: A 11 – 16.[1]

Section 6.—Make the same change as in Section 6 of Specifications A 10 – 16 above.

NO. 7.—NORMALIZING OF COLD-DRAWN RIVET BARS IN SPECIFICATIONS CONTAINING REQUIREMENTS FOR RIVET STEELS.

(*a*) STRUCTURAL STEEL FOR BRIDGES: A 7 – 16.[1]
(*b*) STRUCTURAL NICKEL STEEL: A 8 – 16.[1]
(*c*) STRUCTURAL STEEL FOR BUILDINGS: A 9 – 16.[1]

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[1] 1918 Book of A.S.T.M. Standards.

(*d*) STRUCTURAL STEEL FOR CARS: A 11 – 16.
(*e*) RIVET STEEL FOR SHIPS: A 13 – 14.
(*f*) BOILER RIVET STEEL: A 31 – 14.

Revise each of the above specifications by inserting the provision in the appropriate place that:

> "Tension and bend test specimens for rivet bars which have been cold drawn shall be normalized before testing."

NO. 8.—STANDARD SPECIFICATIONS FOR LAP-WELDED AND SEAMLESS STEEL BOILER TUBES FOR LOCOMOTIVES: A 28 – 18.[1]

1. *Section 6.*—Omit the word "small" before "tubes" in Paragraphs (*a*) and (*b*). In Paragraph (*a*) omit the comma after the word "pipes."

2. *Section 14* (*a*).—Change from its present form, namely:

> "The finished tubes shall be circular within 0.02 in., and the mean outside diameter shall not vary more than 0.015 in. from the size ordered.",

to read as follows:

> "Finished tubes 3½ in. or under in outside diameter shall be circular within 0.02 in. and the mean outside diameter shall not vary more than 0.015 in. from the size ordered. For tubes over 3½ in. in outside diameter, these variations shall not exceed 0.5 per cent of the outside diameter."

NO. 9.—STANDARD SPECIFICATIONS FOR WELDED STEEL PIPE: A 53 – 18.[1]

These specifications have been extensively revised and are appended hereto in their proposed revised form.[2]

NO. 10.—STANDARD SPECIFICATIONS FOR AUTOMOBILE CARBON AND ALLOY STEELS: A 29 – 18.[1]

1. Change the permissible range in chromium in the first three classes in Table IV on Automobile Chromium Steels from 0.65–0.85 to 0.60–0.90 per cent, leaving the desired chromium 0.75 per cent as before.

2. Omit the fourth, fifth and seventh classes in the table

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[1] 1918 Book of A.S.T.M. Standards.

[2] See p. 487.—ED

and substitute therefor the following fully representative type of oil-quenching chromium steel:

	Desired.	Permissible Range.
Carbon, per cent	1.00	0.95 – 1.10
Manganese, "	0.35	0.20 – 0.50
Phosphorus, "		not over 0.03
Sulfur, "		" " 0.03
Chromium, "	1.35	1.20 – 1.50

PROPOSED REVISIONS IN TENTATIVE STANDARDS.

NO. 11.—TENTATIVE SPECIFICATIONS FOR STEEL TIE PLATES: A 67 – 18 T.[1]

Section 10 (b).—Change the first sentence to read as follows by the addition of the italicized figure and the omission of the figure in brackets:

> "For plates with shoulders perpendicular to the direction of rolling, a variation of $\frac{1}{32}$ in. in thickness, [$\frac{1}{8}$] *$\frac{3}{16}$* in. in rolled width, and $\frac{1}{4}$ in. in sheared length will be permitted."

NO. 12.—TENTATIVE SPECIFICATIONS FOR LOW-CARBON-STEEL TRACK BOLTS: A 76 – 18 T.[2]

Section 10.—Make the same change as in Section 11 of Specifications A 50 – 16 above.

NO. 13.—TENTATIVE SPECIFICATIONS FOR STEEL PLATES FOR FORGE WELDING: A 78 – 19 T.[3]

1. *Section 3 (a).*—Change the present requirements as to chemical composition, namely:

Carbon	not over 0.18 per cent
Manganese	0.30 – 0.60 "
Phosphorus	not over 0.04 "
Sulfur	" " 0.05 "

to conform to the following:

Carbon	for plates $\frac{3}{4}$ in. or under in thickness	not over 0.18 per cent
	for plates over $\frac{3}{4}$ in. in thickness	" " 0.20 "
Manganese		0.40 – 0.60 "
Phosphorus		not over 0.04 "
Sulfur		" " 0.05 "

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XIX, Part I, p. 429 (1919).

[2] *Ibid.*, p. 440.

[3] *Ibid.*, p. 448.

2. *Section 6 (a).*—Change the present minimum requirements as to tensile properties, namely:

Tensile strength, lb. per sq. in	for plates ¾ in. or under in thickness	48 000
	plates over ¾ in. in thickness	45 000
Yield point, lb. per sq. in		0.5 Tens. str.
Elongation in 8 in., per cent		$\frac{1\,500\,000}{\text{Tens. str.}}$

to conform to the following:

Tensile strength, lb. per. sq. in	50 000
Yield point, lb. per sq. in	0.5 Tens. str.
Elongation in 8 in., per cent	$\frac{1\,500\,000}{\text{Tens. str.}}$

No. 14.—Tentative Specifications for Carbon Tool Steel: A 71 – 17 T.[1]

1. *Section 1.*—Change to read as follows by the addition of the italicized words and the omission of the words in brackets:

> "1. These specifications cover [carbon tool steel in ten classes and three grades] *three classes of carbon tool steel*, determined by the chemical compositions specified in Section 3."

2. *Section 3.*—(*a*) Change by striking out in the table of chemical properties the ten classes of tool steel with their corresponding percentages of carbon and substituting the following requirements for carbon:

> "The percentage of carbon may vary by ranges of 0.10 per cent with rejection limits plus or minus 0.025 per cent."[2]

(*b*) Change the maximum allowable sulfur in Class A tool steel from 0.02 to 0.025 per cent.

3. *Section 9.*—Change to read as follows by the insertion of the italicized words:

> "Material which does not conform to the chemical composition and agreed variations, or which *at any time* shows injurious defects ***inherent in the steel***, will be rejected, and the contractor shall be notified."

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XIX, Part I, p. 438 (1919).

[2] As an illustration, tool steel may be ordered with a carbon range from 0.60 to 0.70 per cent, with rejection limits of 0.575 and 0.725 per cent, or from 0.75 to 0.85 per cent, with rejection limits of 0.725 and 0.875 per cent.

No. 15.—TENTATIVE SPECIFICATIONS FOR ELECTRIC CAST STEEL ANCHOR CHAIN: A 77 - 18 T.[1]

1. *Section 4 (a).*—Change from its present form, namely:

"For each complete shot of 15 fathoms obtained there shall be cast two test chains consisting of at least one link from each heat entering into the production of that shot of chain. Each link in the test chains shall be properly marked for identification with the heat from which it is poured. The test chains shall contain not less than three links.",

to read as follows:

"Three links shall be selected by the inspector representing the purchaser from any part of each 15 fathoms of chain or portion thereof, and cut out for testing purposes. Such links shall be marked for identification and heat-treated with the length they represent."

2. *Section 4 (c).*—Omit this paragraph, reading as follows:

"(*c*) Both test chains shall be heat-treated with the complete shot of chain which they represent."

3. *Section 6 (b).*—Change to read as follows by the addition of the italicized words and the omission of the words in brackets:

"If any link or links [, not exceeding three] in any one shot of 15 fathoms fail during the proof test, a new link or links may be cast in and the shot retreated and again subjected to the proof tests. [If it passes this retest the shot shall be accepted, provided the new link or links are poured from a heat represented in a test chain which had passed its prescribed breaking tests.] If [it does not pass] ***any link fails on*** this retest the shot shall be rejected."

4. *Section 6 (c).*—Omit this paragraph, reading as follows:

"If more than three links of any one shot of 15 fathoms fail on proof test, the shot shall be rejected."

5. *Section 7.*—Change from its present form to read as follows by the addition of the italicized words:

"In addition to the breaking and proof tests specified in Sections 5 and 6, the material entering into the manufacture of the chain shall be subjected to such shock ***or bend*** tests as shall be agreed upon between the manufacturer and the purchaser, in order to determine its shock-resisting qualities."

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XIX, Part I, p. 444 (1919).

6. *Section 8.*—Change from its present form to read as follows by the omission of the words in brackets:

> "In the event that only one test chain is subjected to test, the remaining test chain may be united with and become a part of another complete shot of chain [, and shall be considered acceptable although not represented by any link in the test chains for the new shot]."

7. *Section 11.*—Change from its present form to read as follows by the addition of the italicized words:

> "*Each link shall be legibly stenciled with its heat number.* Each shot of chain accepted shall be legibly stenciled in accordance with the requirements of the purchaser."

APPENDIX II.

PRELIMINARY PROGRAM OF TESTS

Adopted by the

JOINT COMMITTEE ON INVESTIGATION OF PHOSPHORUS AND SULFUR IN STEEL.

The following program of tests has been adopted by the Joint Committee on Investigation of Phosphorus and Sulfur in Steel, subject to modification as the investigation proceeds:

Material to be Considered.

1. The tests are divided into two series, designated A and B. In each series it is necessary to keep all factors as constant as possible, varying only the percentages of phosphorus and sulfur.

Series A Tests.—Sulfur in All Steels to be "Residual Sulfur."

Group No.	Material.	Carbon, per cent.	Manganese, per cent.	Phosphorus,[1] per cent.	Sulfur,[1] per cent.
1	Rivet Steel, Tubes, etc	0.06–0.12	0.35–0.40	0.02–0.03 0.04–0.05 0.06–0.07	0.03–0.04 0.05–0.06 0.07–0.08
2	Plates and Structural Shapes, including Boiler Plate	0.16–0.22	0.35–0.40	0.03–0.04 0.05–0.06 0.07–0.08	0.03–0.04 0.05–0.06 0.07–0.08
3	Forgings, such as Car Axles, treated and untreated	0.45–0.55	0.50–0.60	0.03–0.04 0.05–0.06 0.07–0.08	0.03–0.04 0.05–0.06 0.07–0.08
4	Wheel, Tire and Rail Steel	0.65–0.75	0.60–0.70	0.03–0.04 0.05–0.06 0.07–0.08	0.03–0.04 0.05–0.06 0.07–0.08
5	Spring Steels	0.95–1.05	0.35–0.45	0.02–0.03 0.04–0.05 0.06–0.07	0.03–0.04 0.05–0.06 0.07–0.08
6	Castings	Compositions to be considered later.			

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[1] With each of the specified ranges of phosphorus it is understood that the sulfur content is to be constant and equal to the usual value for that group of material. (*Vice versa* for sulfur.)

SERIES B TESTS.

In these tests higher percentages of phosphorus and sulfur than are specified in Series A tests shall be used. The purpose of this series is to carry the tests beyond the percentages of impurities specified in Series A, to a point where the material will unquestionably fail from the effect of the higher impurities.

In this series sulfur may be added during the later stages of manufacture, before reaching the mold, the form of the addition to be determined by the committee in charge of the tests. Any heats originally prepared for Series A tests which run too high in phosphorus or sulfur may be diverted to Series B.

2. The tests in Series A cover practically all of the usual ranges of carbon, and of the materials covered in the specifications for which Committee A-1 is responsible. The ranges in phosphorus and sulfur extend up to 0.08 per cent, which is considered to be practicable for present commercial practice. It is considered desirable to investigate first the materials in this series; but the desirability of studying the problem from a more general point of view is recognized by providing for the tests in Series B covering higher limits of these impurities.

The chemical compositions in these tests, other than phosphorus and sulfur, should be typical of the various grades specified.

3. Particular attention is directed to the requirement that the sulfur in the steels of Series A shall be "residual sulfur," that is, sulfur present in the steel through fuel or from pig or scrap. The committee believes that the results of this investigation will be more conclusive and carry more weight if the high sulfur steels in this series are not obtained by the addition of sulfur in the ladle or molds. The opinion is held by many that high sulfur is frequently not harmful *per se* but is indicative of other undesirable conditions in the steel, inherent in the various stages of manufacture; and that these undesirable conditions do not necessarily accompany high sulfur when the latter is obtained by addition in the ladle or mold. It is for this reason that the committee has recommended that the sulfur in the steels of Series A shall be "residual sulfur."

In the steels of Series B it is realized that very high sulfur content could probably not be obtained without such addition. The provision that such addition shall be made before reaching the mold is made because a great number of tests on high sulfur steel where sulfur was added in the mold have been made by J. S. Unger, and the idea of the committee is to endeavor to tie in its investigation with that of Unger in this respect.

4. All of the material in these tests shall be of as uniform quality as possible. Accordingly, segregated tops cuts shall not be used in the tests.

5. In these tests regular heats are desired, that is no special small heats such as one-half ton, etc. A history of each heat shall be obtained and any heat shall be discarded which gives evidence of irregular conditions.

6. In all of the tests, billets shall be rolled down from ingots without allowing the ingots to go cold. The billets of any one group shall be assembled at one plant, and shall be put through the regular manufacturing practice into the shapes to be used, at the same time and under the same conditions.

7. The actual detailed program of tests should be so arranged that it will be possible to concentrate in the beginning on the more urgent problems. Thus the committee suggests that the first heats which should be secured in this program are those of Group 1 on Rivet Steel, Tubes, etc., and Group 2 on Plates and Structural Shapes, etc., considering the sulfur as the variable and the phosphorus as constant. In the meantime, the work of securing data concerning phosphorus and sulfur of all other groups, including service results, should be vigorously carried on. The order of carrying out the program of tests beyond that outlined, and all other details of the investigation, shall be left to the committee in charge of the tests.

NATURE OF TESTS TO BE MADE.

8. The first essential is to secure all possible existing data and service results, including such as can be obtained from abroad. In this work the sub-committees of Committee A-1 can, it is believed, be of very considerable assistance.

9. Laboratory, fabricating and service tests are essential to the study of the effect of phosphorus and sulfur on steel. Laboratory tests unsupported by fabricating or service tests would not, it is believed, be conclusive. In some groups of material, such as structural steels, service tests in the usual sense of that term are difficult; but in those cases laboratory

and certain fabricating tests would give, it is believed, all necessary information.

(*a*) Under laboratory tests should be included, in addition to the necessary chemical analyses, such tests as tension tests, impact and alternating stress tests and metallographic tests, as well as the determination of oxides and gas content. Standard methods of chemical analyses should be followed throughout.

(*b*) Under fabricating tests are included such operations as flanging, punching, drifting, cold pressing, riveting, etc.

(*c*) Service tests should be divided into two classes: Tests on material in service which has given entire satisfaction, including material discarded because it has worn out in service, and tests on material which has failed through inherent defects. In each instance a history of the sample should be obtained.

In connection with service tests emphasis should be laid upon the desirability wherever possible of making tests of full-size parts.

REPORT OF COMMITTEE A-2
ON
WROUGHT IRON.

During the year the committee has held two meetings.

In cooperation with Committee A-1 on Steel, the tables of weights, dimensions and test pressures for standard and extra strong pipe in the Standard Specifications for Welded Wrought-Iron Pipe (A 72-18)[1] have been extended to include sizes from 6 to 12 in. The latter is the present limit of commercial standard sizes.

No agreement has yet been reached regarding specification requirements of bushelled iron and steel-scrap bars.

Definitions of some of the terms used in wrought-iron specifications are presented for publication as tentative.

The users of staybolt iron find that the present permissible variations in diameter sometimes result in bars which are too small to give full threads. A revision of this detail of the Standard Specifications for Staybolt Iron (A 39 - 18)[1] is presented.

Revision of the Standard Specifications for Iron and Steel Chain (A 56 - 18)[1] is still under consideration. What was originally expected to be a slight modification of the table of weights and lengths has developed into a proposal for a radical revision of the entire specifications.

The committee discussed a modification of the Specifications for Wrought-Iron Blooms and Forgings for Locomotives and Cars (A 73 - 18)[1] to insert special requirements for small forgings such as are usually made from rolled bars. The proposal was not approved, the committee considering that the Specifications for Engine-Bolt Iron (A 40 - 18),[1] or those for Extra Refined Wrought-Iron Bars (A 79 - 19 T)[2] are sufficient for the purpose.

For the coming year the committee has under consideration the preparation of a specification for bars made from Bushelled Scrap and the revision of the Chain Specifications (A 56 - 18).

PROPOSED REVISIONS OF STANDARDS.

1. *Specifications for Welded Wrought-Iron Pipe (A 72 - 18).*[1]— It is recommended that Table I on Hydrostatic Pressures and

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[1] 1918 Book of A.S.T.M. Standards.

[2] See p. 522.—Ed.

Table II on Standard Weights be revised to conform to the tables included in this report.[1]

The letter ballot vote of the committee on this recommendation is as follows: Affirmative, 14; negative, 1; not voting, 8.

2. *Specifications for Staybolt Iron* (*A 39 – 18*).[2]—It is recommended that Section 10 be revised to read as follows by the addition of the italized figures and the omission of the figures in brackets:

> "The bars shall be truly round within 0.01 in. and shall not vary more than [0.005] *0.01* in. above nor more than [0.01] *0.005* in. below the specified size."

The letter ballot vote of the committee on this recommendation is as follows: Affirmative, 20; negative, 2; not voting, 1.

PROPOSED NEW STANDARDS.

1. It is recommended that the Tentative Definitions of Terms Relating to Wrought-Iron Specifications appended hereto[3] be accepted for publication as tentative. The letter ballot vote of the committee on this recommendation is as follows: Affirmative, 32; negative, 0; not voting, 11.

This report has been referred to letter ballot of the committee, which consists of 43 members, of whom 32 have voted affirmatively, none negatively, and 11 have refrained from voting.

Respectfully submitted on behalf of the committee,

H. E. SMITH,
Chairman.

J. B. YOUNG,
Secretary.

EDITORIAL NOTE.

The proposed revision of the Standard Specifications for Welded Wrought-Iron Pipe and of the Standard Specifications for Staybolt Iron were accepted for publication as tentative and appear also on pages 813–815.

The proposed Tentative Definitions of Terms Relating to Wrought-Iron Specifications were accepted for publication as tentative and appear on page 527.

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[1] See pp. 514–515.—ED.

[2] 1918 Book of A.S.T.M. Standards.

[3] See p. 527.—ED.

REPORT OF COMMITTEE A-5

ON

CORROSION OF IRON AND STEEL.

The report of Committee A-5 consists of the report of Sub-Committee II on Preservative Metallic Coatings for Metals, of Sub-Committee III on Inspection of Corrosion Tests at Fort Sheridan, Ill., Pittsburgh, Pa., and Annapolis, Md., and the outline of an immersion test of bare sheets in typical waters.

The work of Sub-Committee II on Preservative Metallic Coatings has not progressed as was hoped when the committee was appointed nearly two years ago. Such a test as has been outlined requires relatively large funds to cover the cost of construction of racks and material for test and permanent space for a number of years. From our knowledge of the normal life of galvanized coatings, permanent space for this exposure should be provided which can be insured for at least 10 to 15 years. Such space can probably be obtained under the normal rural conditions in the vicinity of Washington, but space in an active industrial center where corrosion would be rapid, is difficult to obtain. Continued effort will, however, be made to overcome these obstacles as it is felt that the exposure tests of bare metal sheets has reached the point where the results obtained must necessarily be compared with the same sheets when protected with metallic coatings.

The work of Sub-Committee III on Inspection of the Bare Sheets exposed at Fort Sheridan, Ill., Pittsburgh, Pa., and Annapolis, Md., continues to furnish valuable information. During the past year, the first failures have been recorded at Fort Sheridan, and it is interesting to note that the group of sheets which failed at this point are the same as those that failed first at Pittsburgh. Many types of materials have now been eliminated from the Pittsburgh test, as shown in the detailed report of the Inspection Committee. No failures have as yet been reported from the Annapolis test.

The resistance of these various types of metals to immersion in acid waters, saline water, and normal waters was considered of sufficient importance to require another series of tests. Portions of the coupons cut from the sheets exposed in the atmospheric exposure test have been prepared and will be immersed in running, acid, mine water in the Pittsburgh vicinity, in the Severn River at Annapolis, Md., where the salinity is one-quarter to one-third of normal ocean water, and to the City water at Washington, D. C.

The details of this test are contained in the report of Sub-Committee V on Immersion Tests.

This report has been submitted to letter ballot of the committee, which consists of 38 members, of whom 22 have voted affirmatively, none negatively, and 16 have refrained from voting.

Respectfully submitted on behalf of the committee,

S. S. VOORHEES,
Chairman.

J. A. AUPPERLE,
Secretary.

REPORT OF SUB-COMMITTEE II ON PRESERVATIVE METALLIC COATINGS FOR METALS.

Sub-Committee II on Preservative Metallic Coatings for Metals has held two meetings during the past year, October 2, 1919, at Philadelphia, and May 19, 1920, at Philadelphia.

During the year, at the request of Committee A-5, the sub-committee drew up a program of a series of exposure tests of coated sheet metals. These tests are intended to supplement those of the bare sheets now under observation by Sub-Committee III. The program which has been tentatively adopted will be restricted to the various types of commercial coatings as applied to sheets, but as yet it is not ready for publication. The cooperation of some of the largest manufacturers of coated sheets of various types which has been promised for the preparation of the test sheets should expedite the investigation immeasurably. An improved method of testing zinc coatings based upon the principle of the evolution of hydrogen from the coating by means of acid has been perfected during the past year by Dr. A. S. Cushman, a member of the sub-committee, and is described at this annual meeting of the Society.[1] The method has the advantage over other commercial methods in that it does not necessitate the mutilation of the specimen which is being tested and also that it may be carried out in the field or shop after the necessary calibration of the instrument has once been made.

Respectfully submitted on behalf of the sub-committee,

G. K. Burgess,
Chairman.

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[1] A. S. Cushman, "A New Method of Testing Galvanized Coatings," *Proceedings*, Am. Soc. Test. Mats., Vol. XX, Part II (1920).

REPORT OF SUB-COMMITTEE III ON INSPECTION OF THE FORT SHERIDAN, PITTSBURGH AND ANNAPOLIS TESTS.

Sub-Committee III on Inspection has held three meetings during the past year.

FIRST MEETING.

The first meeting was held in Pittsburgh, Pa., on November 5, 1919, with Messrs. Aupperle, Buck, McDonnell, Smith, Wheaton and Gibboney present, Messrs. Cooper, Fleming and the representative of the Bureau of Steam Engineering of the U. S. Navy Department being absent.

The Pittsburgh sheets were inspected on November 5, 1919, followed by inspection of the Annapolis sheets on November 6, 1919. Members filing data sheets for these inspections are as follows:

Pittsburgh.—Messrs. Aupperle, Buck, McDonnell, Smith, Wheaton and Gibboney.

Annapolis.—Messrs. Aupperle, Buck, McDonnell, Smith, Wheaton and Gibboney.

The results of these inspections are shown in composite form as Tables I and II, Plates I and II.

Photographic records of all sheets failing since the last inspection made on April 1, 1919, as well as a few representative groups of sheets showing progressive information on certain sections of the test rack at the Pittsburgh test, were made on November 5, 1919, representing an exposure period of 35 months.

Fig. 1 represents the condition of sheets B 17 and 18 (No. 22 Gage Open-hearth Steel, Series A), sheet B 17 having failed due to a hole in lower end. Sheet B 18 has not failed at this inspection.

Fig. 2 represents the condition of sheets B 35 and 36 (No. 22 Gage Open-hearth Steel, Series A), sheet B 35 having failed due to holes in lower end. Sheet B 36 has not failed at this inspection, the small defect shown in lower end of sheet being a blister.

Fig. 3 represents the condition of progressive corrosion of sheets B 37 and 38 (No. 22 Gage Open-hearth Steel, Series A) reported as failures at the October 7, 1918, and April 1, 1919, inspections respectively.

Figs. 4 to 7, inclusive, represent the condition of sheets C 11 and 12, 13 and 14, 20 and 21, 22 and 32 (No. 22 Gage Copper-Bearing Pure Iron, Series A) sheets C 11, 13, 14, 20 and 22 having failed due to holes in lower ends. Sheets C 12, 21 and 32 have not failed at this inspection.

Figs. 8 to 10, inclusive, represent the condition of sheets E 25 and 26, 27 and 28, 32, 33 and 34 (No. 22 Gage Puddled Iron, Series A), sheets E 25, 32, 33 and 34 having failed due to holes in lower ends. Sheet E 32 was reported as failed at the October 7, 1918 inspection. Sheets E 26 and 28 have not failed at this inspection.

Figs. 11 and 12 represent the condition of sheets T 37 and 38, 39 and 40 (No. 22 Gage Copper-Bearing Open-hearth Steel, Series B), manufactured by the Newport Rolling Mill Co., sheets T 37 and 39 having failed due to holes in lower ends. Sheets T 38 and 40 have not failed at this inspection.

Fig. 13 represents the condition of sheets U 41 and 42 (No. 22 Gage Copper-Bearing Pure Iron, Series B) manufactured by the Allegheny Steel Co., sheet U 41 having failed due to a hole in lower end. Sheet U 42 has not failed at this inspection.

Figs. 14 and 15 represent the condition of Sheets V 29 and 30, 38 and 39 (No. 22 Gage Copper-Bearing Pure Iron, Series B), manufactured by the Whittaker-Glessner Co., sheets V 29 and 39 having failed due to holes in the lower ends. Sheets V 30 and 38 have not failed at this inspection.

Fig. 16 represents the condition of Sheets Y 7, 8 and 9 (No. 22 Gage Low-Copper Wrought Iron, Series B) manufactured by the Youngstown Sheet and Tube Co., having failed due to holes and ragged edges at lower ends. These sheets were placed on test racks on June 2, 1917, and therefore represent an exposure period of 30 months.

Figs. 17 and 18 represent the condition of sheets AA 21 and 22, 23 and 24 (No. 16 Gage Bessemer Steel, Series A), having failed due to ragged edges of lower ends of sheets. All of the AA sheets exposed at this location have now failed.

Figs. 19 to 23, inclusive, represent the condition of progressive corrosion of sheets AA 25, 26 and 27, 28, 29 and 30, 50, 51 and 52, 53 and 54, 55 and 56 (No. 16 Gage Bessemer Steel, Series A) as appearing at this inspection. All of these sheets were reported as failed at the April 1, 1919, inspection.

Fig. 24 represents the condition of sheets SS 33, 34 and 35 (No. 16 Gage Low-Copper Pure Iron, Series B), manufactured by the American Rolling Mill Co. These sheets have not failed at this inspection, the photographic record being made to show condition of very coarse surface texture with loose adhering rust.

Fig. 25 shows the condition of sheets ZZ 8, 10 and 14 (No. 16 Gage Low-Copper Bessemer Steel, Series B), manufactured by the Youngstown Sheet and Tube Co., having failed due to holes and ragged edges at lower ends.

Figs. 26 to 30, inclusive, represent end views of portions of Rows 2, 4, 5, 6 and 7 showing certain groups of sheets as they appeared at the time of this inspection.

All sheets that have failed prior to November 5, 1919, have been photographed and recorded.

The rate of corrosion for the test sheets exposed at Annapolis continues comparatively slow; however, the appearance of the surfaces show some material advance over that reported for the inspection of October 8, 1918. As there were no failures at the Annapolis location, no photographic records were made.

SECOND MEETING.

The second meeting was held at Fort Sheridan, Ill., on December 6, 1919, with Messrs. Aupperle, Buck, Fleming and McDonnell present, Messrs. Cooper, Smith, Wheaton, the representative of the Bureau of Steam Engineering of the U. S. Navy Department, Gibboney, and Voorhees (*ex-officio*) being absent.

The sheets in the tests were found covered with about three inches of snow, making a detail inspection impossible. All four members of the sub-committee present reported:

Sheets O 14, 15 and 21 (No. 22 Gage Low-Copper Open-hearth Steel, Series A) as having failed due to holes in lower end. These sheets have been exposed for a period of 32 months.

No photographic record was made of these failed sheets at this inspection, due to the snow covering the sheets.

THIRD MEETING.

The third meeting was held at Fort Sheridan, Ill., on May 10, 1920, with Messrs. Aupperle, Buck, Fleming, McAdam, representing the Bureau of Steam Engineering of the U. S. Navy Department, McDonnell, Smith, Wheaton, Gibboney and Voorhees (*ex-officio*) present, Mr. Cooper being absent.

The Fort Sheridan sheets were inspected on May 10, 1920, followed by the Pittsburgh sheets on May 11, 1920. Mr. Cooper joined the sub-committee at Pittsburgh. Members filing data sheets for these inspections are as follows:

Fort Sheridan.—Messrs. Aupperle, Buck, Fleming, McAdam, McDonnell, Smith, Wheaton and Gibboney.

Pittsburgh.—Messrs. Aupperle, Buck, Cooper, Fleming, McAdam, McDonnell, Smith, Wheaton and Gibboney.

The results of these inspections are shown in composite form as Tables III and IV, Plates III and IV.

The following photographs of the Fort Sheridan sheets show failures taking place at this location, representing an exposure period of 37 months.

Figs. 31 and 32 represent the condition of sheets A 16 and 17, and 18 (No. 22 Gage Bessemer Steel, Series A) failed due to holes in lower ends.

Fig. 33 to 39, inclusive, represent the condition of sheets O 13 and 14, 15, 16 and 17, 18 and 19, 20 and 21, 22 and 23, and 24 (No. 22 Gage Low-Copper Open-hearth Steel, Series A). Sheets O 13, 16, 19, 23, and 24 have failed due to holes and ragged edges at lower ends. Sheets O 14, 15 and 21 were reported as failed at the December 6, 1919, inspection. Sheets O 17, 18, 20 and 22 have not failed.

Fig. 40 represents the condition of sheets Z 420 and 421 (No. 22 Gage Low-Copper Open-hearth Steel, Series B), manufactured by the Youngstown Sheet and Tube Co., Sheet Z 421 failed due to holes and ragged edges at lower end. Sheet Z 420 has not failed.

The following photographs of the Pittsburgh sheets show failures taking place since the November 6, 1919, inspection, representing an exposure period of 41 months, as well as other conditions specificially mentioned.

Figs. 41 and 42 represent the condition of sheets B 17 and 18, 35 and 36 (No. 22 Gage Open-hearth Steel, Series A). Sheets B 17, 18 and 36 have failed due to holes in lower end. Sheet B 35 was reported as failed at the November 5, 1919, inspection.

Figs. 43 to 45, inclusive, represent the condition of sheets C 21 and 22, 32 and 33, 34 and 35 (No. 22 Gage Copper-Bearing Pure Iron, Series A). Sheets C 21, 32, 34 and 35 have failed due to holes in lower ends. Sheet C 22 was reported as failed at the November 5, 1919, inspection. Sheet C 33 has not failed.

Figs. 46 and 47 represent the condition of sheets E 25 and 26, 27 and 28 (No. 22 Gage Puddled Iron, Series A). Sheets E 26 and 28 have failed due to holes in lower ends. Sheets E 25 and 27 were reported as failed at the November 5, 1919, inspection.

Figs. 48 to 50, inclusive, represent the condition of sheets M 31 and 32, 35 and 36, 41 and 42 (No. 22 Gage Open-hearth Steel, Series B), manufactured by the Alan Wood Iron and Steel Co. Sheets 32, 36 and 42 have failed due to holes in the lower ends. Sheets 31, 35 and 41 have not failed.

Figs. 51 to 54, inclusive, represent the condition of sheets T 31 and 32, 33 and 34, 35 and 36, 37 and 38 (No. 22 Gage Copper-Bearing Steel, Series B), manufactured by the Newport Rolling Mill Co. Sheets 32, 33, 35, 36 and 38 have failed due to holes in the lower ends. Sheet T 37 was reported as failed at the November 5, 1919, inspection. Sheet T 31 and 34 have not failed.

Figs. 55 and 56 represent the condition of sheets U 29 and 30, 40 and 41 (No. 22 Gage Copper-Bearing Pure Iron, Series B), manufactured by the Allegheny Steel Co., failed due to holes in the lower ends.

Figs. 57 and 58 represent the condition of sheets V 36 and 37, 41 and 42 (No. 22 Gage Copper-Bearing Pure Iron, Series B), manufactured by the Whittaker-Glessner Co. Sheets V 36, 37 and 42 have failed due to holes in lower ends. Sheet V 41 has not failed.

Figs. 59 and 60 represent the condition of sheets AA 21 and 22, 23 and 24 (No. 16 Gage Bessemer Steel, Series A), reported

Date of Inspection *November 5, 1919*

ROW No. 1

Mark	Sheet No.	Texture									Color									Adherence								
		1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 Mc.Adam	7 Mc.Donnell	8 Smith	9 Wheaton	1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 Mc.Adam	7 Mc.Donnell	8 Smith	9 Wheaton	1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 Mc.Adam	7 Mc.Donnell	8 Smith	9 Wheaton
AA	21	VC	VC			VC		VC	C	VC	L	L			L		L	L	M	L	L			L		L	L	L
	22	VC	VC			VC		VC	C	VC	L	L			L		L	L	M	L	L			L		L	L	L
	23	VC	VC			VC		VC	C	VC	L	L			L		L	L	M	L	L			L		L	L	L
	24	VC	VC			VC		VC	VC	VC	L	L			L		L	L	M	L	L			L		L	L	L
BB	8	S	S			S		S	VS	S	D	D			D		D	D	D	T	T			T		T	T	T
	9	S	S			S		S	VS	S	D	D			D		D	D	D	T	T			T		T	T	T
	20	M	M			M		M	S	M	D	M			M		M	D	D	T	L			L		T	T	T
	21	M	M			M		M	S	M	D	M			M		M	D	D	T	L			L		T	T	T
CC	15	C	C			C		M	M	M	M	M			M		M	M	D	TL	L			T		T	T	T
	16	C	C			C		M	M	M	M	M			M		M	M	D	TL	L			T		T	T	T
	17	C	C			C		M	M	M	M	M			M		M	M	D	TL	L			T		T	T	T
	18	C	C			C		M	M	M	M	M			M		M	M	D	TL	L			T		T	T	T
DD	25	C	VC			VC		C	C	C	M	L			M		M	M	M	L	L			L		T	L	L
	26	C	VC			VC		C	C	C	M	L			M		M	M	M	L	L			L		T	L	L
	27	C	VC			VC		C	C	C	M	L			M		M	M	M	L	L			L		T	L	L
	28	C	VC			VC		C	C	C	M	L			M		M	M	M	L	L			L		T	L	L
EE※	13	S	S			S		S	S	S	D	D			D		D	D	D	T	T			T		T	T	T
	14	S	S			S		S	S	S	D	D			D		D	D	D	T	T			T		T	T	T
	15	S	S			S		S	S	S	D	D			D		D	D	D	T	T			T		T	T	T
	16	S	S			S		S	S	S	D	D			D		D	D	D	T	T			T		T	T	T
HH	19	S	S			S		S	VS	S	D	D			D		D	D	D	T	T			T		T	T	T
	20	S	S			S		S	VS	S	D	D			D		D	D	D	T	T			T		T	T	T
	21	S	S			S		S	VS	S	D	D			D		D	D	D	T	T			T		T	T	T
	22	S	S			S		S	VS	S	D	D			D		D	D	D	T	T			T		T	T	T
II	20	S	VS			VS		VS	VS	S	D	D			D		D	D	D	T	T			T		T	T	T
	21	S	VS			VS		VS	VS	S	D	D			D		D	D	D	T	T			T		T	T	T
	22	S	VS			VS		VS	VS	S	D	D			D		D	D	D	T	T			T		T	T	T
	23	S	VS			VS		VS	VS	S	D	D			D		D	D	D	T	T			T		T	T	T
KK	6	S	VS			S		VS	VS	VS	D	D			D		D	D	D	T	T			T		T	T	T
	7	S	VS			S		VS	VS	VS	D	D			D		D	D	D	T	T			T		T	T	T
	8	S	VS			S		VS	VS	VS	D	D			D		D	D	D	T	T			T		T	T	T
	27	S	VS			S		VS	VS	VS	D	D			D		D	D	D	T	T			T		T	T	T
MM※	29	M	M			M		C	S	M	M	D			M		M	M	D	T	TL			T		T	T	T
	30	M	M			M		C	S	M	M	D			M		M	M	D	T	TL			T		T	T	T
	31	M	M			M		C	S	M	M	D			M		M	M	D	T	TL			T		T	T	T
	32	M	M			M		C	S	M	M	D			M		M	M	D	T	TL			T		T	T	T
SS	29	VC	VC			VC		VC	VC	VC	L	L			L		L	L	L	L	L			L		L	L	L
	30	VC	VC			VC		VC	VC	VC	L	L			L		L	L	L	L	L			L		L	L	L
	31	VC	VC			VC		VC	VC	VC	L	L			L		L	L	L	L	L			L		L	L	L
	32	VC	VC			VC		VC	VC	VC	L	L			L		L	L	L	L	L			L		L	L	L
TT	29	M	S			S		VS	S	VS	D	D			D		D	M	D	T	T			T		T	T	T
	30	M	S			S		VS	S	VS	D	D			D		D	M	D	T	T			T		T	T	T
	31	M	S			S		VS	S	VS	D	D			D		D	M	D	T	T			T		T	T	T
	32	M	S			S		VS	S	VS	D	D			D		D	M	D	T	T			T		T	T	T
UU	29	S	S			S		S	S	S	D	D			M		D	M	D	T	T			T		T	T	T
	30	S	S			S		S	S	S	D	D			M		D	M	D	T	T			T		T	T	T
	31	S	S			S		S	S	S	D	D			M		D	M	D	T	T			T		T	T	T
	32	S	S			S		S	S	S	D	D			M		D	M	D	T	T			T		T	T	T
VV	39	S	S			S		S	S	S	D	D			M		D	D	D	T	T			T		T	T	T
	40	S	S			S		S	S	S	D	D			M		D	D	D	T	T			T		T	T	T
	41	S	S			S		S	S	S	D	D			M		D	D	D	T	T			T		T	T	T
	42	S	S			S		S	S	S	D	D			M		D	D	D	T	T			T		T	T	T
XX	29	VC	VC			VC		VC	VC	VC	L	L			L		L	L	M	L	L			L		L	L	L
	30	VC	VC			VC		VC	VC	VC	L	L			L		L	L	M	L	L			L		L	L	L
	31	VC	VC			VC		VC	VC	VC	L	L			L		L	L	M	L	L			L		L	L	L
	32	VC	VC			VC		VC	VC	VC	L	L			L		L	L	M	L	L			L		L	L	L
OO	25	C	C			C		C	M	C	M	L			M		M	M	D	L	L			L		L	L	T
	26	C	C			C		C	M	C	M	L			M		M	M	D	L	L			L		L	L	T
	27	C	C			C		C	M	C	M	L			M		M	M	D	L	L			L		L	L	T
	28	C	C			C		C	M	C	M	L			M		M	M	D	L	L			L		L	L	T
YYY	1	S	S			S		M	VS	S	D	D			D		D	M	D	T	T			T		T	T	T
	2	S	S			S		M	VS	S	D	D			D		D	M	D	T	T			T		T	T	T
	3	S	S			S		M	VS	S	D	D			D		D	M	D	T	T			T		T	T	T
	4	S	S			S		M	VS	S	D	D			D		D	M	D	T	T			T		T	T	T
ZZ	8	C	VC			C		C	C	M	L	L			L		L	M	M	L	L			L		L	L	T
	10	C	VC			C		C	C	M	L	L			L		L	M	M	L	L			L		L	L	T
	14	C	VC			C		C	C	M	L	L			L		L	M	M	L	L			L		L	L	T
	102	VS	VS			S		S	VS	S	D	D			M		D	D	M	T	T			T		T	T	T
	310	VS	VS			VS		S	VS	S	D	D			D		D	D	M	T	T			T		T	T	T
	311	VS	VS			VS		S	VS	S	D	D			D		D	D	M	T	T			T		T	T	T

† Open Annealed.

ROW No. 2

Mark	Sheet No.	Texture									Color									Adherence								
		1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 Mc.Adam	7 Mc.Donnell	8 Smith	9 Wheaton	1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 Mc.Adam	7 Mc.Donnell	8 Smith	9 Wheaton	1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 Mc.Adam	7 Mc.Donnell	8 Smith	9 Wheaton
A	31	VC	*			*		*	*	C	L	*			*		*	*	D	L	*			*		*	*	L
	32	VC	*			*		*	*	C	L	*			*		*	*	D	L	*			*		*	*	L
	33	VC	*			*		*	*	C	L	*			*		*	*	D	L	*			*		*	*	L
	34	VC	*			*		*	*	C	L	*			*		*	*	D	L	*			*		*	*	L
B	17	C	M			M		C	M	M	D	D			D		D	D	D	T	L			T		T	L	T
	18	C	M			M		C	M	M	D	D			D		D	D	D	T	L			T		T	L	T
	19	C	M			M		C	M	M	D	D			D		D	D	D	T	L			T		T	L	T
	20	C	M			M		C	M	M	D	D			D		D	D	D	T	L			T		T	L	T
C	11	M	C			M		C	C	M	M	D			D		M	D	D	T	L			T		T	L	T
	12	M	C			M		C	C	M	M	D			D		M	D	D	T	L			T		T	L	T
	13	M	C			M		C	C	M	M	D			D		M	D	D	T	L			T		T	L	T
	14	M	C			M		C	C	M	M	D			D		M	D	D	T	L			T		T	L	T
D	30	VC	*			*		*	*	VC	L	*			*		*	*	M	L	*			*		*	*	T
	31	VC	*			*		*	*	VC	L	*			*		*	*	M	L	*			*		*	*	T
	33	VC	*			*		*	*	VC	L	*			*		*	*	M	L	*			*		*	*	T
	34	VC	*			*		*	*	VC	L	*			*		*	*	M	L	*			*		*	*	T
E	25	S	M			C		C	M	M	D	D			D		D	D	D	T	TL			T		T	L	T
	26	S	M			C		C	M	M	D	D			D		D	D	D	T	TL			T		T	L	T
	27	S	M			C		C	M	M	D	D			D		D	D	D	T	TL			T		T	L	T
	28	S	M			C		C	M	M	D	D			D		D	D	D	T	TL			T		T	L	T
H	38	S	M			S		M	M	M	D	D			D		D	D	D	T	T			T		T	L	T
	40	S	M			S		M	M	M	D	D			D		D	D	D	T	T			T		T	L	T
	41	S	M			S		M	M	M	D	D			D		D	D	D	T	T			T		T	L	T
	42	S	M			S		M	M	M	D	D			D		D	D	D	T	T			T		T	L	T
I	38	M	S			VS		S	S	M	M	D			D		D	D	D	T	T			T		T	T	T
	39	M	S			VS		S	S	M	M	D			D		D	D	D	T	T			T		T	T	T
	40	M	S			VS		S	S	M	M	D			D		D	D	D	T	T			T		T	T	T
	41	M	S			VS		S	S	M	M	D			D		D	D	D	T	T			T		T	T	T
K	33	M	S			VS		S	S	M	D	D			D		D	D	D	T	T			T		T	T	T
	34	M	S			VS		S	S	M	D	D			D		D	D	D	T	T			T		T	T	T
	35	M	S			VS		S	S	M	D	D			D		D	D	D	T	T			T		T	T	T
	36	M	S			VS		S	S	M	D	D			D		D	D	D	T	T			T		T	T	T
M	29	M	M			M		M	M	M	D	D			D		D	D	D	T	TL			T		T	L	T
	30	M	M			M		M	M	M	D	D			D		D	D	D	T	TL			T		T	L	T
	31	M	M			M		M	M	M	D	D			D		D	D	D	T	TL			T		T	L	T
	32	M	M			M		M	M	M	D	D			D		D	D	D	T	TL			T		T	L	T
S	29	VC	*			*		*	*	VC	L	*			*		*	*	M	L	*			*		*	*	L
	30	VC	*			*		*	*	VC	L	*			*		*	*	M	L	*			*		*	*	L
	31	VC	*			*		*	*	VC	L	*			*		*	*	M	L	*			*		*	*	L
	32	VC	*			*		*	*	VC	L	*			*		*	*	M	L	*			*		*	*	L
T	29	S	M			S		S	M	M	D	D			D		D	D	D	T	T			T		T	L	T
	30	S	M			S		S	M	M	D	D			D		D	D	D	T	T			T		T	L	T
	31	S	M			S		S	M	M	D	D			D		D	D	D	T	T			T		T	L	T
	32	S	M			S		S	M	M	D	D			D		D	D	D	T	T			T		T	L	T
U	29	S	M			S		S	M	M	D	D			D		D	M	D	T	TL			T		T	L	T
	30	S	M			S		S	M	M	D	D			D		D	M	D	T	TL			T		T	L	T
	31	S	M			S		S	M	M	D	D			D		D	M	D	T	TL			T		T	L	T
	32	S	M			S		S	M	M	D	D			D		D	M	D	T	TL			T		T	L	T
V	29	S	M			M		M	M	M	D	D			D		D	D	D	T	TL			T		T	L	T
	30	S	M			M		M	M	M	D	D			D		D	D	D	T	TL			T		T	L	T
	31	S	M			M		M	M	M	D	D			D		D	D	D	T	TL			T		T	L	T
	32	S	M			M		M	M	M	D	D			D		D	D	D	T	TL			T		T	L	T
X	29	VC	*			*		*	*	VC	M	*			*		*	*	D	L	*			*		*	*	L
	30	VC	*			*		*	*	VC	M	*			*		*	*	D	L	*			*		*	*	L
	31	VC	*			*		*	*	VC	M	*			*		*	*	D	L	*			*		*	*	L
	32	VC	*			*		*	*	VC	M	*			*		*	*	D	L	*			*		*	*	L
O	25	*	*			*		*	*	*	*	*			*		*	*	*	L	*			*		*	*	*
	26	*	*			*		*	*	*	*	*			*		*	*	*	L	*			*		*	*	*
	27	*	*			*		*	*	*	*	*			*		*	*	*	L	*			*		*	*	*
	28	*	*			*		*	*	*	*	*			*		*	*	*	L	*			*		*	*	*
Z	6	VC	VC			*		*	*	VC	M	L			*		*	*	*	L	L			*		*	*	*
	7	VC	VC			*		*	*	VC	M	L			*		*	*	*	L	L			*		*	*	*
	11	VC	VC			*		*	*	VC	M	L			*		*	*	*	L	L			*		*	*	*
	111	VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	T	T
	112	VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	T	T
	113	VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	T	T
	209	VS	VS			S		S	S	M	D	D			D		D	D	D	T	T			T		T	T	T
	213	VS	VS			S		S	S	M	D	D			D		D	D	D	T	T			T		T	T	T
	214	VS	VS			S		S	S	M	D	D			D		D	D	D	T	T			T		T	T	T
	310	VS	VS			S		S	S	M	D	D			D		D	D	D	T	T			T		T	T	T

ROW No. 3

Mark	Sheet No.	Texture									Color									Adherence								
		1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 Mc.Adam	7 Mc.Donnell	8 Smith	9 Wheaton	1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 Mc.Adam	7 Mc.Donnell	8 Smith	9 Wheaton	1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 Mc.Adam	7 Mc.Donnell	8 Smith	9 Wheaton
AA	25	VC	VC			*		*	*	C	L	L			*		*	*	M	L	L			*		*	*	T
	26	VC	VC			*		*	*	C	L	L			*		*	*	M	L	L			*		*	*	T
	27	VC	VC			*		*	*	C	L	L			*		*	*	M	L	L			*		*	*	T
	28	VC	VC			*		*	*	C	L	L			*		*	*	M	L	L			*		*	*	T
	29	VC	VC			*		*	*	C	L	L			*		*	*	M	L	L			*		*	*	T
	30	VC	VC			*		*	*	C	L	L			*		*	*	M	L	L			*		*	*	T
AA※	50	VC	VC			*		*	*	VC	L	L			*		*	*	M	L	L			*		*	*	L
	51	VC	VC			*		*	*	VC	L	L			*		*	*	M	L	L			*		*	*	L
	52	VC	VC			*		*	*	VC	L	L			*		*	*	M	L	L			*		*	*	L
	53	VC	VC			*		*	*	VC	L	L			*		*	*	M	L	L			*		*	*	L
	54	VC	VC			*		*	*	VC	L	L			*		*	*	M	L	L			*		*	*	L
	55	VC	VC			*		*	*	VC	L	L			*		*	*	M	L	L			*		*	*	L
	56	VC	VC			*		*	*	VC	L	L			*		*	*	M	L	L			*		*	*	L
BB	22	C	M			C		C	C	C	D	D			D		D	D	D	T	L			T		T	L	T
	23	C	M			C		C	C	C	D	D			D		D	D	D	T	L			T		T	L	T
	24	C	M			C		C	C	C	D	D			D		D	D	D	T	L			T		T	L	T
	40	C	S			M		M	M	M	D	D			M		D	M	D	T	T			T		T	L	T
	41	C	S			M		M	M	M	D	D			M		D	M	D	T	T			T		T	L	T
BB※	33	C	S			M		M	M	M	D	D			D		D	D	D	T	T			T		T	L	T
	34	C	S			M		M	M	M	D	D			D		D	D	D	T	T			T		T	L	T
	35	C	S			M		M	M	M	D	D			D		D	D	D	T	T			T		T	L	T
	36	C	S			M		M	M	M	D	D			D		D	D	D	T	T			T		T	L	T
	50	C	S			M		M	M	M	D	D			D		D	D	D	T	T			T		T	L	T
	51	C	S			M		M	M	M	D	D			D		D	D	D	T	T			T		T	L	T
	52	C	S			M		M	M	M	D	D			D		D	D	D	T	T			T		T	L	T
	53	C	S			M		M	M	M	D	D			D		D	D	D	T	T			T		T	L	T
CC	7	C	C			C		C	C	C	M	D			M		M	M	D	T	L			L		L	L	T
	19	C	C			C		C	C	C	M	D			M		M	M	D	T	L			L		L	L	T
CC※	31	C	C			C		C	C	C	M	D			M		M	M	D	T	L			L		L	L	T
	32	C	C			C		C	C	C	M	D			M		M	M	D	T	L			L		L	L	T
	33	C	C			C		C	C	C	M	D			M		M	M	D	T	L			L		L	L	T
	34	C	C			C		C	C	C	M	D			M		M	M	D	T	L			L		L	L	T
	35	C	C			C		C	C	C	M	D			M		M	M	D	T	L			L		L	L	T
	36	C	C			C		C	C	C	M	D			M		M	M	D	T	L			L		L	L	T
DD	8	C	VC			VC		VC	VC	C	M	D			M		M	M	D	L	L			L		L	L	T
	9	C	VC			VC		VC	VC	C	M	D			M		M	M	D	L	L			L		L	L	T
	18	C	VC			VC		VC	VC	C	M	D			M		M	M	D	L	L			L		L	L	T
	29	C	VC			VC		VC	VC	C	M	D			M		M	M	D	L	L			L		L	L	T
	30	C	VC			VC		VC	VC	C	M	D			M		M	M	D	L	L			L		L	L	T
	31	C	VC			VC		VC	VC	C	M	D			M		M	M	D	L	L			L		L	L	T
DD※	47	C	VC			VC		C	VC	C	M	D			M		M	M	D	L	L			L		L	L	T
	48	C	VC			VC		C	VC	C	M	D			M		M	M	D	L	L			L		L	L	T
	49	C	VC			VC		C	VC	C	M	D			M		M	M	D	L	L			L		L	L	T
	54	C	VC			VC		C	C	C	M	D			M		M	M	D	L	L			L		L	L	T
	55	C	VC			VC		C	C	C	M	D			M		M	M	D	L	L			L		L	L	T
	56	C	VC			VC		C	C	C	M	D			M		M	M	D	L	L			L		L	L	T
	57	C	VC			VC		C	C	C	M	D			M		M	M	D	L	L			L		L	L	T
	58	C	VC			VC		C	C	C	M	D			M		M	M	D	L	L			L		L	L	T
EE†	17	VS	S			S		S	S	S	D	D			D		D	D	D	T	T			T		T	L	T
	18	VS	S			S		S	S	S	D	D			D		D	D	D	T	T			T		T	L	T
EE※†	31	VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	L	T
	32	VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	L	T
	33	VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	L	T
	34	VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	L	T
	35	VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	L	T
	36	VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	L	T
HH	23	VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	L	T
	24	VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	L	T
	25	VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	L	T
	26	VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	L	T
HH※	43	VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	L	T
	44	VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	L	T
	45	VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	L	T
	46	VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	L	T
	47	VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	L	T
	48	VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	L	T
	49	VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	L	T
II	24	VS	VS			S		VS	VS	S	D	D			D		D	D	D	T	T			T		T	T	T
	25	VS	VS			S		VS	VS	S	D	D			D		D	D	D	T	T			T		T	T	T
	27	VS	VS			S		VS	VS	S	D	D			D		D	D	D	T	T			T		T	T	T
	28	VS	VS			S		VS	VS	S	D	D			D		D	D	D	T	T			T		T	T	T
	29	VS	VS			S		VS	VS	S	D	D			D		D	D	D	T	T			T		T	T	T

※ Sand Blasted.

† Open Annealed.

CONDITION OF RUST.

Texture	Color	Adherence
VS—Very Smooth	L—Light	T—Tight
S—Smooth	M—Medium	L—Loose
M—Medium	D—Dark	M—Medium
C—Coarse		
VC—Very Coarse		

— INSPECTION COMMITTEE —

J. H. Gibboney, Chairman — Norfolk & Western Ry.
J. A. Aupperle — American Rolling Mill Co.
D. M. Buck — American Sheet & Tin Plate Co.
W. A. Cooper — Alan Wood Iron & Steel Co.
W. R. Fleming — The Andrews Steel Co.
D. J. Mc. Adam, Jr. — U. S. Navy, Bureau Steam Engineering.
M. E. Mc. Donnell — Pennsylvania Railroad Co.
H. E. Smith — New York Central Railroad Co.
F. B. Wheaton — U. S. Army, Quartermaster's Corps.

NOTES: — General —

Sheets marked with a Star (*) under "Condition of
were not considered for Detail Physical Inspection Due
Previously Reported Failure.

All of the A, D, O, S, X and AA Sheets Exposed at this L
are Complete Failures.

The Following Sheets have Failed due to Development o
or Ragged Edges at Lower Ends, since April 1, 1919, the
Previous Inspection:
AA-21, 22, 23, 24. ZZ-8, 10, 14. B-17, 35. C-11, 13, 14, 20, 22.
V-29, 39. Z-11, 422, 423, 424. T-37, 39. U-41. Y

TABLE I.—RESULTS OF INSPECTION OF CORROSION TEST SHEETS,

AMERICAN SOCIETY FOR TESTING

COMMITTEE A-5 ON CORROSION OF IRON AN
TESTS OF UNCOATED SHEETS
PITTSBURGH, PA.

EXPOSED DECEMBER 12, 1918.

Date of Inspection *November 5, 1919.*

Texture									Color									Adherence								
Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc.Adam 6	Mc.Donnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc.Adam 6	Mc.Donnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc.Adam 6	Mc.Donnell 7	Smith 8	Wheaton 9
VC	VC			*		*	*	C	L	L			*		*	*	M	L	L			*		*	*	T
VC	VC			*		*	*	C	L	L			*		*	*	M	L	L			*		*	*	T
VC	VC			*		*	*	C	L	L			*		*	*	M	L	L			*		*	*	T
VC	VC			*		*	*	C	L	L			*		*	*	M	L	L			*		*	*	T
VC	VC			*		*	*	C	L	L			*		*	*	M	L	L			*		*	*	T
VC	VC			*		*	*	C	L	L			*		*	*	M	L	L			*		*	*	T
VC	VC			*		*	*	VC	L	L			*		*	*	M	L	L			*		*	*	L
VC	VC			*		*	*	VC	L	L			*		*	*	M	L	L			*		*	*	L
VC	VC			*		*	*	VC	L	L			*		*	*	M	L	L			*		*	*	L
VC	VC			*		*	*	VC	L	L			*		*	*	M	L	L			*		*	*	L
VC	VC			*		*	*	VC	L	L			*		*	*	M	L	L			*		*	*	L
VC	VC			*		*	*	VC	L	L			*		*	*	M	L	L			*		*	*	L
VC	VC			*		*	*	VC	L	L			*		*	*	M	L	L			*		*	*	L
C	M			C		C	C	C	D	D			D		D	D	D	T	L			T		T	L	T
C	M			C		C	C	C	D	D			D		D	D	D	T	L			T		T	L	T
C	M			C		C	C	C	D	D			D		D	D	D	T	L			T		T	L	T
C	S			M		M	M	M	D	D			M		D	M	D	T	T			T		T	L	T
C	S			M		M	M	M	D	D			M		D	M	D	T	T			T		T	L	T
C	S			M		M	M	M	D	D			D		D	D	D	T	T			T		T	L	T
C	S			M		M	M	M	D	D			D		D	D	D	T	T			T		T	L	T
C	S			M		M	M	M	D	D			D		D	D	D	T	T			T		T	L	T
C	S			M		M	M	M	D	D			D		D	D	D	T	T			T		T	L	T
C	S			M		M	M	M	D	D			D		D	D	D	T	T			T		T	L	T
C	S			M		M	M	M	D	D			D		D	D	D	T	T			T		T	L	T
C	S			M		M	M	M	D	D			D		D	D	D	T	T			T		T	L	T
C	S			M		M	M	M	D	D			D		D	D	D	T	T			T		T	L	T
C	C			C		C	C	C	M	D			M		M	M	D	T	L			L		L	L	T
C	C			C		C	C	C	M	D			M		M	M	D	T	L			L		L	L	T
C	C			C		C	C	C	M	D			M		M	M	D	T	L			L		L	L	T
C	C			C		C	C	C	M	D			M		M	M	D	T	L			L		L	L	T
C	C			C		C	C	C	M	D			M		M	M	D	T	L			L		L	L	T
C	C			C		C	C	C	M	D			M		M	M	D	T	L			L		L	L	T
C	C			C		C	C	C	M	D			M		M	M	D	T	L			L		L	L	T
C	C			C		C	C	C	M	D			M		M	M	D	T	L			L		L	L	T
C	VC			VC		VC	VC	C	M	D			M		M	M	D	L	L			L		L	L	T
C	VC			VC		VC	VC	C	M	D			M		M	M	D	L	L			L		L	L	T
C	VC			VC		VC	VC	C	M	D			M		M	M	D	L	L			L		L	L	T
C	VC			VC		VC	VC	C	M	D			M		M	M	D	L	L			L		L	L	T
C	VC			VC		VC	VC	C	M	D			M		M	M	D	L	L			L		L	L	T
C	VC			VC		VC	VC	C	M	D			M		M	M	D	L	L			L		L	L	T
C	VC			VC		C	VC	C	M	D			M		M	M	D	L	L			L		L	L	T
C	VC			VC		C	VC	C	M	D			M		M	M	D	L	L			L		L	L	T
C	VC			VC		C	VC	C	M	D			M		M	M	D	L	L			L		L	L	T
C	VC			VC		C	C	C	M	D			M		M	M	D	L	L			L		L	L	T
C	VC			VC		C	C	C	M	D			M		M	M	D	L	L			L		L	L	T
C	VC			VC		C	C	C	M	D			M		M	M	D	L	L			L		L	L	T
C	VC			VC		C	C	C	M	D			M		M	M	D	L	L			L		L	L	T
C	VC			VC		C	C	C	M	D			M		M	M	D	L	L			L		L	L	T
VS	S			S		S	S	S	D	D			D		D	D	D	T	T			T		T	L	T
VS	S			S		S	S	S	D	D			D		D	D	D	T	T			T		T	L	T
VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	L	T
VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	L	T
VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	L	T
VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	L	T
VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	L	T
VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	L	T
VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	L	T
VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	L	T
VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	L	T
VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	L	T
VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	L	T
VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	L	T
VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	L	T
VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	L	T
VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	L	T
VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	L	T
VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	L	T
VS	VS			S		VS	VS	S	D	D			D		D	D	D	T	T			T		T	T	T
VS	VS			S		VS	VS	S	D	D			D		D	D	D	T	T			T		T	T	T
VS	VS			S		VS	VS	S	D	D			D		D	D	D	T	T			T		T	T	T
VS	VS			S		VS	VS	S	D	D			D		D	D	D	T	T			T		T	T	T
VS	VS			S		VS	VS	S	D	D			D		D	D	D	T	T			T		T	T	T

ROW No. 4

DESIGNATION		CONDITION OF RUST																										
		Texture									Color									Adherence								
Mark	Sheet No.	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc.Adam 6	Mc.Donnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc.Adam 6	Mc.Donnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc.Adam 6	Mc.Donnell 7	Smith 8	Wheaton 9
II*	48	VS	VS			VS		VS	S	S	D	D			D		D	D	D	T	T			T		T	T	T
	49	VS	VS			VS		VS	S	S	D	D			D		D	D	D	T	T			T		T	T	T
	50	VS	VS			VS		VS	S	S	D	D			D		D	D	D	T	T			T		T	T	T
	51	VS	VS			VS		VS	S	S	D	D			D		D	D	D	T	T			T		T	T	T
	52	VS	VS			VS		VS	S	S	D	D			D		D	D	D	T	T			T		T	T	T
	53	VS	VS			VS		VS	S	S	D	D			D		D	D	D	T	T			T		T	T	T
	54	VS	VS			VS		VS	S	S	D	D			D		D	D	D	T	T			T		T	T	T
	55	VS	VS			VS		VS	S	S	D	D			D		D	D	D	T	T			T		T	T	T
	56	VS	VS			VS		VS	S	S	D	D			D		D	D	D	T	T			T		T	T	T
KK	28	VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	L	T
	29	VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	L	T
	30	VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	L	T
	31	VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	L	T
	32	VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	L	T
	33	VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	L	T
	34	VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	L	T
KK*	51	VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	L	T
	52	VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	L	T
	53	VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	L	T
	54	VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	L	T
	55	VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	L	T
	56	VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	L	T
	57	VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	L	T
	58	VS	S			S		S	S	M	D	D			D		D	D	D	T	T			T		T	L	T
MM†	33	C	C			C		M	C	C	D	D			D		D	D	D	L	L			L		T	L	T
	34	C	C			C		M	C	C	D	D			D		D	D	D	L	L			L		T	L	T
	35	C	C			C		M	C	C	D	D			D		D	D	D	L	L			L		T	L	T
	36	C	C			C		M	C	C	D	D			D		D	D	D	L	L			L		T	L	T
	37	C	C			C		M	C	C	D	D			D		D	D	D	L	L			L		T	L	T
	38	C	C			C		M	C	C	D	D			D		D	D	D	L	L			L		T	L	T
	39	C	C			C		M	C	C	D	D			D		D	D	D	L	L			L		T	L	T
	40	C	C			C		M	C	C	D	D			D		D	D	D	L	L			L		T	L	T
	41	C	C			C		M	C	C	D	D			D		D	D	D	L	L			L		T	L	T
	42	C	C			C		M	C	C	D	D			D		D	D	D	L	L			L		T	L	T
SS	33	VC	VC			VC		VC	VC	VC	M	L			L		L	M	M	L	L			L		L	L	L
	34	VC	VC			VC		VC	VC	VC	M	L			L		L	M	M	L	L			L		L	L	L
	35	VC	VC			VC		VC	VC	VC	M	L			L		L	M	M	L	L			L		L	L	L
	36	VC	VC			VC		VC	VC	VC	M	L			L		L	M	M	L	L			L		L	L	L
	37	VC	VC			VC		VC	VC	VC	M	L			L		L	M	M	L	L			L		L	L	L
	38	VC	VC			VC		VC	VC	VC	M	L			L		L	M	M	L	L			L		L	L	L
	39	VC	VC			VC		VC	VC	VC	M	L			L		L	M	M	L	L			L		L	L	L
	40	VC	VC			VC		VC	VC	VC	M	L			L		L	M	M	L	L			L		L	L	L
	41	VC	VC			VC		VC	VC	VC	M	L			L		L	M	M	L	L			L		L	L	L
	42	VC	VC			VC		VC	VC	VC	M	L			L		L	M	M	L	L			L		L	L	L
TT	33	S	M			S		S	M	M	D	D			D		D	D	D	T	T			T		T	L	T
	34	S	M			S		S	M	M	D	D			D		D	D	D	T	T			T		T	L	T
	35	S	M			S		S	M	M	D	D			D		D	D	D	T	T			T		T	L	T
	36	S	M			S		S	M	M	D	D			D		D	D	D	T	T			T		T	L	T
	37	S	M			S		S	M	M	D	D			D		D	D	D	T	T			T		T	L	T
	38	S	M			S		S	M	M	D	D			D		D	D	D	T	T			T		T	L	T
	39	S	M			S		S	M	M	D	D			D		D	D	D	T	T			T		T	L	T
	40	S	M			S		S	M	M	D	D			D		D	D	D	T	T			T		T	L	T
	41	S	M			S		S	M	M	D	D			D		D	D	D	T	T			T		T	L	T
	42	S	M			S		S	M	M	D	D			D		D	D	D	T	T			T		T	L	T
UU	33	M	M			S		S	M	M	D	D			D		D	M	D	T	T			T		T	TL	T
	34	M	M			S		S	M	M	D	D			D		D	M	D	T	T			T		T	TL	T
	35	M	M			S		S	M	M	D	D			D		D	M	D	T	T			T		T	TL	T
	36	M	M			S		S	M	M	D	D			D		D	M	D	T	T			T		T	TL	T
	37	M	M			S		S	M	M	D	D			D		D	M	D	T	T			T		T	TL	T
	38	M	M			S		S	M	M	D	D			D		D	M	D	T	T			T		T	TL	T
	39	M	M			S		S	M	M	D	D			D		D	M	D	T	T			T		T	TL	T
	40	M	M			S		S	M	M	D	D			D		D	M	D	T	T			T		T	TL	T
	41	M	M			S		S	M	M	D	D			D		D	M	D	T	T			T		T	TL	T
	42	M	M			S		S	M	M	D	D			D		D	M	D	T	T			T		T	TL	T
VV	43	M	M			M		S	S	M	D	D			D		D	M	D	T	T			T		T	T	T
	44	M	M			M		S	S	M	D	D			D		D	M	D	T	T			T		T	T	T
	45	M	M			M		S	S	M	D	D			D		D	M	D	T	T			T		T	T	T
	46	M	M			M		S	S	M	D	D			D		D	M	D	T	T			T		T	T	T
	47	M	M			M		S	S	M	D	D			D		D	M	D	T	T			T		T	T	T
	48	M	M			M		S	S	M	D	D			D		D	M	D	T	T			T		T	T	T
	49	M	M			M		S	S	M	D	D			D		D	M	D	T	T			T		T	T	T
	50	M	M			M		S	S	M	D	D			D		D	M	D	T	T			T		T	T	T
	51	M	M			M		S	S	M	D	D			D		D	M	D	T	T			T		T	T	T

ROW No. 5

DESIGNATION		CONDITION OF RUST																										
		Texture									Color									Adherence								
Mark	Sheet No.	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc.Adam 6	Mc.Donnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc.Adam 6	Mc.Donnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc.Adam 6	Mc.Donnell 7	Smith 8	Wheaton 9
XX	33	VC	VC			VC		VC	VC	C	M	M			M		L	M	D	L	L			L		L	L	L
	34	VC	VC			VC		VC	VC	C	M	M			M		L	M	D	L	L			L		L	L	L
	35	VC	VC			VC		VC	VC	C	M	M			M		L	M	D	L	L			L		L	L	L
	36	VC	VC			VC		VC	VC	C	M	M			M		L	M	D	L	L			L		L	L	L
	37	VC	VC			VC		VC	VC	C	M	M			M		L	M	D	L	L			L		L	L	L
	38	VC	VC			VC		VC	VC	C	M	M			M		L	M	D	L	L			L		L	L	L
	39	VC	VC			VC		VC	VC	C	M	M			M		L	M	D	L	L			L		L	L	L
	40	VC	VC			VC		VC	VC	C	M	M			M		L	M	D	L	L			L		L	L	L
	41	VC	VC			VC		VC	VC	C	M	M			M		L	M	D	L	L			L		L	L	L
	42	VC	VC			VC		VC	VC	C	M	M			M		L	M	D	L	L			L		L	L	L
ZZ	208	VS	S			VS		S	S	S	D	D			D		D	D	D	T	T			T		T	L	L
	209	VS	S			VS		S	S	S	D	D			D		D	D	D	T	T			T		T	L	L
	213	VS	S			VS		S	S	S	D	D			D		D	D	D	T	T			T		T	L	L
	314	VS	S			VS		S	S	S	D	D			D		D	D	D	T	T			T		T	L	L
	426	C	C			C		C	C	M	M	D			M		M	D	D	L	L			L		L	L	L
	427	C	C			C		C	C	M	M	D			M		M	D	D	L	L			L		L	L	L
	507	S	VS			VS		S	S	S	D	D			D		D	D	D	T	T			T		T	T	L
	510	S	VS			VS		S	S	S	D	D			D		D	D	D	T	T			T		T	T	L
	509	S	VS			VS		S	S	S	D	D			D		D	D	D	T	T			T		T	T	L
	612	S	VS			VS		S	S	S	D	D			D		D	D	D	T	T			T		T	T	L
	614	S	VS			VS		S	S	S	D	D			D		D	D	D	T	T			T		T	T	L
	615	S	VS			VS		S	S	S	D	D			D		D	D	D	T	T			T		T	T	L
	714	S	VS			VS		S	S	S	D	D			D		D	D	D	T	T			T		T	T	L
	715	S	VS			VS		S	S	S	D	D			D		D	D	D	T	T			T		T	T	L
OO	29	VC	C			C		VC	C	C	D	M			M		M	M	D	L	L			L		L	L	T
	30	VC	C			C		VC	C	C	D	M			M		M	M	D	L	L			L		L	L	T
	31	VC	C			C		VC	C	C	D	M			M		M	M	D	L	L			L		L	L	T
	32	VC	C			C		VC	C	C	D	M			M		M	M	D	L	L			L		L	L	T
	33	VC	C			C		VC	C	C	D	M			M		M	M	D	L	L			L		L	L	T
	34	VC	C			C		VC	C	C	D	M			M		M	M	D	L	L			L		L	L	T
	35	VC	C			C		VC	C	C	D	M			M		M	M	D	L	L			L		L	L	T
	36	VC	C			C		VC	C	C	D	M			M		M	M	D	L	L			L		L	L	T
CCC	5	M	M			M		M	M	M	M	M			D		D	M	D	T	L			T		T	L	T
	6	M	M			M		M	M	M	M	M			D		D	M	D	T	L			T		T	L	T
	7	M	M			M		M	M	M	M	M			D		D	M	D	T	L			T		T	L	T
	8	M	M			M		M	M	M	M	M			D		D	M	D	T	L			T		T	L	T
	9	M	M			M		M	M	M	M	M			D		D	M	D	T	L			T		T	L	T
	10	M	M			M		M	M	M	M	M			D		D	M	D	T	L			T		T	L	T
	11	M	M			M		M	M	M	M	M			D		D	M	D	T	L			T		T	L	T
	12	M	M			M		M	M	M	M	M			D		D	M	D	T	L			T		T	L	T
A	35	VC	*			*		*	*	C	M	*			*		*	*	D	L	*			*		*	*	L
	36	VC	*			*		*	*	C	M	*			*		*	*	D	L	*			*		*	*	L
	37	VC	*			*		*	*	C	M	*			*		*	*	D	L	*			*		*	*	L
	38	VC	*			*		*	*	C	M	*			*		*	*	D	L	*			*		*	*	L
	39	VC	*			*		*	*	C	M	*			*		*	*	D	L	*			*		*	*	L
	40	VC	*			*		*	*	C	M	*			*		*	*	D	L	*			*		*	*	L
	41	VC	*			*		*	*	C	M	*			*		*	*	D	L	*			*		*	*	L
	42	VC	*			*		*	*	C	M	*			*		*	*	D	L	*			*		*	*	L
	43	VC	*			*		*	*	C	M	*			*		*	*	D	L	*			*		*	*	L
	44	VC	*			*		*	*	C	M	*			*		*	*	D	L	*			*		*	*	L
	45	VC	*			*		*	*	C	M	*			*		*	*	D	L	*			*		*	*	L
	46	VC	*			*		*	*	C	M	*			*		*	*	D	L	*			*		*	*	L
	47	VC	*			*		*	*	C	M	*			*		*	*	D	L	*			*		*	*	L
B	21	M	M			M		M	M	M	D	D			D		D	D	D	T	TL			T		L	L	L
	22	M	M			M		M	M	M	D	D			D		D	D	D	T	TL			T		L	L	L
	23	M	M			M		M	M	M	D	D			D		D	D	D	T	TL			T		L	L	L
	34	M	S			M		M	M	M	D	D			D		D	D	D	T	TL			T		L	L	L
	35	M	C			M		M	M	C	D	D			D		D	D	D	T	L			T		L	L	L
	36	M	C			M		M	M	C	D	D			D		D	D	D	T	L			T		L	L	L
	37	M	C			M		M	M	C	D	D			D		D	D	D	T	L			T		L	L	L
	38	M	C			M		M	M	C	D	D			D		D	D	D	T	L			T		L	L	L
	39	M	M			M		M	M	M	D	D			D		D	D	D	T	TL			T		L	L	L
C	20	C	M			M		M	M	C	M	D			D		D	M	D	T	TL			T		T	L	L
	21	C	M			M		M	M	C	M	D			D		D	M	D	T	TL			T		T	L	L
	22	C	M			M		M	M	C	M	D			D		D	M	D	T	TL			T		T	L	L
	32	C	M			M		M	M	C	M	D			D		D	M	D	T	TL			T		T	L	L
	33	C	M			M		M	M	C	M	D			D		D	M	D	T	TL			T		T	L	L
	34	C	M			M		M	M	C	M	D			D		D	M	D	T	TL			T		T	L	L
	35	C	M			M		M	M	C	M	D			D		D	M	D	T	TL			T		T	L	L

ROW No. 6

DESIGNATION		CONDITION OF RUST					
		Texture					
Mark	Sheet No.	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc.Adam 6
D	35	C	*			*	
	36	C	*			*	
	38	C	*			*	
	39	C	*			*	
	40	C	*			*	
E	29	S	M			M	
	30	S	M			M	
	31	S	M			M	
	32	S	M			M	
	33	S	M			M	
	34	S	M			M	
	35	S	M			M	
	36	S	M			M	
H	43	S	M			S	
	45	S	M			S	
	47	S	M			S	
	49	S	M			S	
	50	S	M			S	
	53	S	M			S	
	54	S	M			S	
	55	S	M			S	
I	42	S	VS			S	
	43	S	VS			S	
	44	S	VS			S	
	45	S	VS			S	
	46	S	VS			S	
	47	S	VS			S	
	48	S	VS			S	
	49	S	VS			S	
	50	S	VS			S	
	51	S	VS			S	
	52	S	VS			S	
	53	S	VS			S	
	54	S	VS			S	
	56	S	VS			S	
K	37	S	S			S	
	38	S	S			S	
	39	S	S			S	
	40	S	S			S	
	41	S	S			S	
	42	S	S			S	
	43	S	S			S	
	44	S	S			S	
	45	S	S			S	
	46	S	S			S	
	47	S	S			S	
	48	S	S			S	
M	33	S	M			M	
	34	S	M			M	
	35	S	M			M	
	36	S	M			M	
	37	S	M			M	
	38	S	M			M	
	39	S	M			M	
	40	S	M			M	
	41	S	M			M	
	42	S	M			M	
S	33	VC	*			*	
	34	VC	*			*	
	35	VC	*			*	
	36	VC	*			*	
	37	VC	*			*	
	38	VC	*			*	
	39	VC	*			*	
	40	VC	*			*	
	41	VC	*			*	
	42	VC	*			*	

* Sand Blasted.

† Open Annealed.

— General —

Sheets marked with a Star (*) under "Condition of Rust"
ere not considered for Detail Physical Inspection Due to
reviously Reported Failure.

All of the A, D, O, S, X and AA Sheets Exposed at this Location
re Complete Failures.

The Following Sheets have Failed due to Development of Holes
r Ragged Edges at Lower Ends, since April 1, 1919, the Date of
revious Inspection :
A-21,22,23,24. ZZ-8,10,14. B-17,35. C-11,13,14,20,22. E-25,27,33,34.
-29,39. Z-11,422,423,424. T-37,39. U-41. Y-7,8,9.

— J. A. AUPPERLE —

AA — 21-24 incl. Failure.
CC — 17- Laminated.
ZZ — 8,10,14-Failure, Ragged.
B — 17- Failure.
C — 11,13,14- „
E — 25,27- „
U — 29- „
Z — 6,7,11- „
AA — 25-30-incl. „
AA* — 50-56- „ „
B — 35,37,38- Failure.
C — 20,22 - „
E — 29-36 incl. Failure.
T — 37,39 - Failure.
U — 41- „
V — 37,39- „
Z — 422,423,424 - Failure.
Y* — 7,8,9- Failure.

— D. M. BUCK —

AA — 21-24 incl. Failure.
CC — 17-Laminated.
DD — 25-28 incl. near Failure.
SS — 29-32 „ „ „
XX — 29-32 „ „ „
ZZ — 8,10,14-Failure.
B — 17- „
C — 11,13,14- „
E — 25-27 „
V — 29- „
Z — 6,7,11 „
AA — 25-30 incl. Failure.
AA* — 50-5
SS — 33-4
XX — 33-4
B — 35,37
C — 20,2
E — 29-3
T — 37,3
U — 41-
V — 39-
Z — 422,4
Y* — 7,8,

ETS, AT PITTSBURGH, PA., NOVEMBER 5, 1919.

STING MATERIALS
RON AND STEEL
EETS

Weather *Cloudy and Cold.*

Texture							Color									Adherence								
3 Cooper	4 Fleming	5 Gibboney	6 Mc.Adam	7 Mc.Donnell	8 Smith	9 Wheaton	1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 Mc.Adam	7 Mc.Donnell	8 Smith	9 Wheaton	1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 Mc.Adam	7 Mc.Donnell	8 Smith	9 Wheaton
		*		*	*	C	M	*			*		*	*	D	L	*			*		*	*	T
		*		*	*	C	M	*			*		*	*	D	L	*			*		*	*	T
		*		*	*	C	M	*			*		*	*	D	L	*			*		*	*	T
		*		*	*	C	M	*			*		*	*	D	L	*			*		*	*	T
		*		*	*	C	M	*			*		*	*	D	L	*			*		*	*	T
		M		*	M	M	D	D			D		*	D	D	T	T			T		*	T	T
		M		*	M	M	D	D			D		*	D	D	T	T			T		*	T	T
		M		*	M	M	D	D			D		*	D	D	T	T			T		*	T	T
		M		*	M	M	D	D			D		*	D	D	T	T			T		*	T	T
		M		*	M	M	D	D			D		*	D	D	T	T			T		*	T	T
		M		*	M	M	D	D			D		*	D	D	T	T			T		*	T	T
		M		*	M	M	D	D			D		*	D	D	T	T			T		*	T	T
		M		*	M	M	D	D			D		*	D	D	T	T			T		*	T	T
		S		S	M	M	D	D			D		D	D	D	T	T			T		T	T	T
		S		S	M	M	D	D			D		D	D	D	T	T			T		T	T	T
		S		S	M	M	D	D			D		D	D	D	T	T			T		T	T	T
		S		S	M	M	D	D			D		D	D	D	T	T			T		T	T	T
		S		S	M	M	D	D			D		D	D	D	T	T			T		T	T	T
		S		S	M	M	D	D			D		D	D	D	T	T			T		T	T	T
		S		S	M	M	D	D			D		D	D	D	T	T			T		T	T	T
		S		S	M	M	D	D			D		D	D	D	T	T			T		T	T	T
		S		S	S	S	D	D			D		D	D	D	T	T			T		T	T	T
		S		S	S	S	D	D			D		D	D	D	T	T			T		T	T	T
		S		S	S	S	D	D			D		D	D	D	T	T			T		T	T	T
		S		S	S	S	D	D			D		D	D	D	T	T			T		T	T	T
		S		S	S	S	D	D			D		D	D	D	T	T			T		T	T	T
		S		S	S	S	D	D			D		D	D	D	T	T			T		T	T	T
		S		S	S	S	D	D			D		D	D	D	T	T			T		T	T	T
		S		S	S	S	D	D			D		D	D	D	T	T			T		T	T	T
		S		S	S	S	D	D			D		D	D	D	T	T			T		T	T	T
		S		S	S	S	D	D			D		D	D	D	T	T			T		T	T	T
		S		S	S	S	D	D			D		D	D	D	T	T			T		T	T	T
		S		S	S	S	D	D			D		D	D	D	T	T			T		T	T	T
		S		S	S	S	D	D			D		D	D	D	T	T			T		T	T	T
		S		S	S	S	D	D			D		D	D	D	T	T			T		T	T	T
		S		S	S	M	D	D			D		D	D	D	T	T			T		T	T	T
		S		S	S	M	D	D			D		D	D	D	T	T			T		T	T	T
		S		S	S	M	D	D			D		D	D	D	T	T			T		T	T	T
		S		S	S	M	D	D			D		D	D	D	T	T			T		T	T	T
		S		S	S	M	D	D			D		D	D	D	T	T			T		T	T	T
		S		S	S	M	D	D			D		D	D	D	T	T			T		T	T	T
		S		S	S	M	D	D			D		D	D	D	T	T			T		T	T	T
		S		S	S	M	D	D			D		D	D	D	T	T			T		T	T	T
		S		S	S	M	D	D			D		D	D	D	T	T			T		T	T	T
		S		S	S	M	D	D			D		D	D	D	T	T			T		T	T	T
		S		S	S	M	D	D			D		D	D	D	T	T			T		T	T	T
		S		S	S	M	D	D			D		D	D	D	T	T			T		T	T	T
		M		S	M	M	M	D			D		D	D	D	T	TL			T		T	L	T
		M		S	M	M	M	D			D		D	D	D	T	TL			T		T	L	T
		M		S	M	M	M	D			D		D	D	D	T	TL			T		T	L	T
		M		S	M	M	M	D			D		D	D	D	T	TL			T		T	L	T
		M		S	M	M	M	D			D		D	D	D	T	TL			T		T	L	T
		M		S	M	M	M	D			D		D	D	D	T	TL			T		T	L	T
		M		S	M	M	M	D			D		D	D	D	T	TL			T		T	L	T
		M		S	M	M	M	D			D		D	D	D	T	TL			T		T	L	T
		M		S	M	M	M	D			D		D	D	D	T	TL			T		T	L	T
		M		S	M	M	M	D			D		D	D	D	T	TL			T		T	L	T
		*		*	*	VC	M	*			*		*	*	M	L	*			*		*	*	L
		*		*	*	VC	M	*			*		*	*	M	L	*			*		*	*	L
		*		*	*	VC	M	*			*		*	*	M	L	*			*		*	*	L
		*		*	*	VC	M	*			*		*	*	M	L	*			*		*	*	L
		*		*	*	VC	M	*			*		*	*	M	L	*			*		*	*	L
		*		*	*	VC	M	*			*		*	*	M	L	*			*		*	*	L
		*		*	*	VC	M	*			*		*	*	M	L	*			*		*	*	L
		*		*	*	VC	M	*			*		*	*	M	L	*			*		*	*	L
		*		*	*	VC	M	*			*		*	*	M	L	*			*		*	*	L
		*		*	*	VC	M	*			*		*	*	M	L	*			*		*	*	L

ROW No. 7

Designation		Texture									Color									Adherence								
Mark	Sheet No.	1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 Mc.Adam	7 Mc.Donnell	8 Smith	9 Wheaton	1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 Mc.Adam	7 Mc.Donnell	8 Smith	9 Wheaton	1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 Mc.Adam	7 Mc.Donnell	8 Smith	9 Wheaton
T	33	S	M			S		S	S	M	D	D			D		D	D	D	T	T			T		T	T	T
	34	S	M			S		S	S	M	D	D			D		D	D	D	T	T			T		T	T	T
	35	S	M			S		S	S	M	D	D			D		D	D	D	T	T			T		T	T	T
	36	S	M			S		S	S	M	D	D			D		D	D	D	T	T			T		T	T	T
	37	S	M			S		S	S	M	D	D			D		D	D	D	T	T			T		T	T	T
	38	S	M			S		S	S	M	D	D			D		D	D	D	T	T			T		T	T	T
	39	S	M			S		S	S	M	D	D			D		D	D	D	T	T			T		T	T	T
	40	S	M			S		S	S	M	D	D			D		D	D	D	T	T			T		T	T	T
	41	S	M			S		S	S	M	D	D			D		D	D	D	T	T			T		T	T	T
	42	S	M			S		S	S	M	D	D			D		D	D	D	T	T			T		T	T	T
U	33	S	M			S		S	S	M	D	D			D		D	D	D	T	T			T		T	T	T
	34	S	M			S		S	S	M	D	D			D		D	D	D	T	T			T		T	T	T
	35	S	M			S		S	S	M	D	D			D		D	D	D	T	T			T		T	T	T
	36	S	M			S		S	S	M	D	D			D		D	D	D	T	T			T		T	T	T
	37	S	M			S		S	S	M	D	D			D		D	D	D	T	T			T		T	T	T
	38	S	M			S		S	S	M	D	D			D		D	D	D	T	T			T		T	T	T
	39	S	M			S		S	M	M	D	D			D		D	D	D	T	T			T		T	L	T
	40	S	M			S		S	M	M	D	D			D		D	D	D	T	T			T		T	L	T
	41	S	M			M		S	M	M	D	D			D		D	D	D	T	T			L		T	L	T
	42	S	M			M		S	M	M	D	D			D		D	D	D	T	T			L		T	L	T
V	33	S	M			M		S	M	M	D	D			D		D	M	D	T	T			T		T	L	T
	34	S	M			M		S	M	M	D	D			D		D	M	D	T	T			T		T	L	T
	35	S	M			M		S	M	M	D	D			D		D	M	D	T	T			T		T	L	T
	36	S	M			M		S	M	M	D	D			D		D	M	D	T	T			T		T	L	T
	37	S	M			M		S	M	M	D	D			D		D	M	D	T	T			T		T	L	T
	38	S	M			M		S	M	M	D	D			D		D	M	D	T	T			T		T	L	T
	39	S	M			M		S	M	M	D	D			D		D	M	D	T	T			T		T	L	T
	40	S	M			M		S	M	M	D	D			D		D	M	D	T	T			T		T	L	T
	41	S	M			M		S	M	M	D	D			D		D	M	D	T	T			T		T	L	T
	42	S	M			M		S	M	M	D	D			D		D	M	C	T	T			T		T	L	T
X	33	M	*			*		*	*	VC	M	*			*		*	*	D	T	*			*		*	*	L
	34	M	*			*		*	*	VC	M	*			*		*	*	D	T	*			*		*	*	L
	35	M	*			*		*	*	VC	M	*			*		*	*	D	T	*			*		*	*	L
	36	M	*			*		*	*	VC	M	*			*		*	*	D	T	*			*		*	*	L
	37	M	*			*		*	*	VC	M	*			*		*	*	D	T	*			*		*	*	L
	38	M	*			*		*	*	VC	M	*			*		*	*	D	T	*			*		*	*	L
	39	M	*			*		*	*	VC	M	*			*		*	*	D	T	*			*		*	*	L
	40	M	*			*		*	*	VC	M	*			*		*	*	D	T	*			*		*	*	L
	41	M	*			*		*	*	VC	M	*			*		*	*	D	T	*			*		*	*	L
	42	M	*			*		*	*	VC	M	*			*		*	*	D	T	*			*		*	*	L
Z	314	VS	S			VS		S	S	S	D	D			D		D	D	D	T	T			T		T	T	T
	422	VC	VC			*		*	*	VC	M	L			*		*	*	D	L	L			*		*	*	T
	423	VC	VC			*		*	*	VC	M	L			*		*	*	D	L	L			*		*	*	T
	424	VC	VC			*		*	*	VC	M	L			*		*	*	D	L	L			*		*	*	T
	509	VS	VS			VS		S	S	S	D	D			D		D	D	D	T	T			T		T	T	T
	513	VS	VS			VS		S	S	S	D	D			D		D	D	D	T	T			T		T	T	T
	516	VS	VS			VS		S	S	S	D	D			D		D	D	D	T	T			T		T	T	T
	607	VS	VS			VS		S	S	M	D	D			D		D	D	D	T	T			T		T	T	T
	608	VS	VS			VS		S	S	M	D	D			D		D	D	D	T	T			T		T	T	T
	609	VS	VS			VS		S	S	M	D	D			D		D	D	D	T	T			T		T	T	T
	712	VS	VS			VS		S	S	S	D	D			D		D	D	D	T	T			T		T	T	T
	714	VS	VS			VS		S	S	S	D	D			D		D	D	D	T	T			T		T	T	T
	715	VS	VS			VS		S	S	S	D	D			D		D	D	D	T	T			T		T	T	T
O	29	*	*			*		*	*	*	*	*			*		*	*	*	*	*			*		*	*	*
	30	*	*			*		*	*	*	*	*			*		*	*	*	*	*			*		*	*	*
	31	*	*			*		*	*	*	*	*			*		*	*	*	*	*			*		*	*	*
	32	*	*			*		*	*	*	*	*			*		*	*	*	*	*			*		*	*	*
	33	*	*			*		*	*	*	*	*			*		*	*	*	*	*			*		*	*	*
	34	*	*			*		*	*	*	*	*			*		*	*	*	*	*			*		*	*	*
	35	*	*			*		*	*	*	*	*			*		*	*	*	*	*			*		*	*	*
	36	*	*			*		*	*	*	*	*			*		*	*	*	*	*			*		*	*	*
Y*	7	C	VC			C		VC	C	C	M	D			M		M	M	D	L	L			L		L	L	T
	8	C	VC			C		VC	C	C	M	D			M		M	M	D	L	L			L		L	L	T
	9	C	VC			C		VC	C	C	M	D			M		M	M	D	L	L			L		L	L	T
YY*	7	C	VC			C		VC	VC	VC	M	D			M		L	M	D	L	L			L		L	L	T
	8	C	VC			C		VC	VC	VC	M	D			M		L	M	D	L	L			L		L	L	T
	9	C	VC			C		VC	VC	VC	M	D			M		L	M	D	L	L			L		L	L	T

— H. E. SMITH —

AA — 21-24 incl., Failure.
CC — 17- Split.
ZZ — 8, 10, 14- Failure.
B — 17, 13, 20- ” .
C — 11, 13, 14- ” .
E — 25, 27- ” .
V — 29— ” .
Z — 6, 7, 11- ” .
AA — 25-30 incl., Failure.
AA* — 50-56 ” ” ” .
B — 35, 37, 38- ” .
C — 20, 22- ” .
E — 29-36 incl., Failure.
T — 37-39- Failures.
U — 41- Failure.
V — 39- ” .
Z — 422, 423, 424- Failures.
Y* — 7, 8, 9 — Failure.

Expired 6-2-17.

— 50-56 incl. Failure.
— 33-42 ” near Failure.
— 33-42 ” ” ” .
— 35, 37, 38- Failure.
— 20, 22- ” .
— 29-36 incl. ” .
— 37, 39- ” .
— 41- ” .
— 39- ” .
— 422, 423, 424- Failure.
— 7, 8, 9- ” .

Cooper, Fleming and Mc.Adam did not make this Inspection.

— J. H. GIBBONEY —

AA — 21-24 incl. Failure.
CC — 17- Split.
ZZ — 8, 10, 14- Failure.
B — 17, 19, 20- ” .
C — 11, 13, 14- ” .
E — 25, 27- ” .
V — 29- ” .
Z — 6, 7, 11- ” .
AA — 25-30 incl. ” .
AA* — 50-56 ” ” .
B — 35, 37, 38- ” .
C — 20, 22- ” .
E — 29-36 incl. Failure.
T — 37, 39- Failure.
U — 41- ” .
V — 39- ” .
Z — 422, 423, 424- Failure.
Y* — 7, 8, 9- Failure.

— M. E. Mc. DONN

AA — 21-24 incl., Failure, Lower End.
DD — 28- Crack on Left Side; Accidental.
ZZ — 8-10-14- Failure, Lower End.
B — 17- Hole near Bottom.
C — 11, 14- One Hole.
C — 13- Two Holes.
E — 25- One Hole.
E — 27- Three Holes.
V — 29- Two ” ; ½" x 2".
Z — 6, 7, 11- Failure.
AA — 25-30 incl. Failure.
AA* — 50-56 ” ” .

Weather *Cloudy and Cold.*

CONDITION OF RUST																	
Color									Adherence								
1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 Mc. Adam	7 Mc. Donnell	8 Smith	9 Wheaton	1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 Mc. Adam	7 Mc. Donnell	8 Smith	9 Wheaton
D	D			D		D	D	D	T	T			T		T	T	T
D	D			D		D	D	D	T	T			T		T	T	T
D	D			D		D	D	D	T	T			T		T	T	T
D	D			D		D	D	D	T	T			T		T	T	T
D	D			D		D	D	D	T	T			T		T	T	T
D	D			D		D	D	D	T	T			T		T	T	T
D	D			D		D	D	D	T	T			T		T	T	T
D	D			D		D	D	D	T	T			T		T	T	T
D	D			D		D	D	D	T	T			T		T	T	T
D	D			D		D	D	D	T	T			T		T	T	T
D	D			D		D	D	D	T	T			T		T	T	T
D	D			D		D	D	D	T	T			T		T	T	T
D	D			D		D	D	D	T	T			T		T	T	T
D	D			D		D	D	D	T	T			T		T	T	T
D	D			D		D	D	D	T	T			T		T	T	T
D	D			D		D	D	D	T	T			T		T	T	T
D	D			D		D	D	D	T	T			T		T	L	T
D	D			D		D	D	D	T	T			T		T	L	T
D	D			D		D	D	D	T	T			L		T	L	T
D	D			D		D	D	D	T	T			L		T	L	T
D	D			D		D	M	D	T	T			T		T	L	T
D	D			D		D	M	D	T	T			T		T	L	T
D	D			D		D	M	D	T	T			T		T	L	T
D	D			D		D	M	D	T	T			T		T	L	T
D	D			D		D	M	D	T	T			T		T	L	T
D	D			D		D	M	D	T	T			T		T	L	T
D	D			D		D	M	D	T	T			T		T	L	T
D	D			D		D	M	D	T	T			T		T	L	T
D	D			D		D	M	D	T	T			T		T	L	T
D	D			D		D	M	D	T	T			T		T	L	T
	*			*		*	*	D	T	*			*		*	*	L
	*			*		*	*	D	T	*			*		*	*	L
	*			*		*	*	D	T	*			*		*	*	L
	*			*		*	*	D	T	*			*		*	*	L
	*			*		*	*	D	T	*			*		*	*	L
	*			*		*	*	D	T	*			*		*	*	L
	*			*		*	*	D	T	*			*		*	*	L
	*			*		*	*	D	T	*			*		*	*	L
	*			*		*	*	D	T	*			*		*	*	L
	*			*		*	*	D	T	*			*		*	*	L
	D			D		D	D	D	T	T			T		T	T	T
	L			*		*	*	D	L	L			*		*	*	T
	L			*		*	*	D	L	L			*		*	*	T
	L			*		*	*	D	L	L			*		*	*	T
	D			D		D	D	D	T	T			T		T	T	T
	D			D		D	D	D	T	T			T		T	T	T
	D			D		D	D	D	T	T			T		T	T	T
	D			D		D	D	D	T	T			T		T	T	T
	D			D		D	D	D	T	T			T		T	T	T
	D			D		D	D	D	T	T			T		T	T	T
	D			D		D	D	D	T	T			T		T	T	T
	D			D		D	D	D	T	T			T		T	T	T
	D			D		D	D	D	T	T			T		T	T	T
	*			*		*	*	*	*	*			*		*	*	*
	*			*		*	*	*	*	*			*		*	*	*
	*			*		*	*	*	*	*			*		*	*	*
	*			*		*	*	*	*	*			*		*	*	*
	*			*		*	*	*	*	*			*		*	*	*
	*			*		*	*	*	*	*			*		*	*	*
	*			*		*	*	*	*	*			*		*	*	*
	*			*		*	*	*	*	*			*		*	*	*
	D			M		M	M	D	L	L			L		L	L	T
	D			M		M	M	D	L	L			L		L	L	T
	D			M		M	M	D	L	L			L		L	L	T
	D			M		L	M	D	L	L			L		L	L	T
	D			M		L	M	D	L	L			L		L	L	T
	D			M		L	M	D	L	L			L		L	L	T

— H. E. SMITH —

AA — 21-24 incl., Failure.
CC — 17- Split.
ZZ — 8, 10, 14- Failure.
B — 17, 19, 20- ,, .
C — 11, 13, 14- ,, .
E — 25, 27- ,, .
V — 29 — ,, .
Z — 6, 7, 11- ,, .
AA — 25-30 incl., Failure.
AA* — 50-56 ,, ,, ,, .
B — 35, 37, 38- ,, .
C — 20, 22 - ,, .
E — 29-36 incl., Failure.
T — 37-39- Failures.
U — 41- Failure.
V — 39- ,, .
Z — 422, 423, 424 - Failures.
Y* — 7, 8, 9 — Failure.

— F. B. WHEATON —

AA — 21-24 incl., Failure.
CC — 17- Laminated.
ZZ — 8, 10, 14,- Failure.
B — 17- Hole 4" from Bottom.
C — 11- ,, 10" ,, ,, .
C — 13, 14 - Holes 8" from Bottom.
E — 25 — Hole 10" ,, ,, .
E — 27- Three Holes, 10" from Bottom.
V — 29- Holes, 8" and 12" ,, ,, .
Z — 6, 7, 11- Failure, Hanging to Top Bar.
AA — 25-30. incl., Failure.
AA* — 50-56 ,, , Failure.
B — 35, 37, 38- Failure.
C — 20- Hole 6" from Bottom.
C — 22 - Two Holes.
E — 29-36 incl., Failures.
I — 50- Bullet Hole.
T — 37, 39- Failures.
U — 41- Hole 7" from Bottom.
V — 39- Cracked 12" up.
V — 40 - Bullet Hole.
Z — 422, 423, 424 - Failures.
Y* — 7, 8, 9- Failures.

— J. H. GIBBONEY —

AA — 21-24 incl. Failure.
CC — 17- Split.
ZZ. — 8, 10, 14 - Failure.
B — 17, 19, 20- ,, .
C — 11, 13, 14 - ,, .
E — 25, 27- ,, .
V — 29- ,, .
Z — 6, 7, 11 - ,, .
AA — 25-30 incl. ,, .
AA* — 50-56 ,, ,, .
B — 35, 37, 38- ,, .
C — 20, 22 - ,, .
E — 29-36 incl. Failure.
T — 37, 39- Failure.
U — 41- ,, .
V — 39- ,, .
Z — 422, 423, 424 - Failure.
Y* — 7, 8, 9 - Failure.

— M. E. MC. DONNELL —

AA — 21-24 incl., Failure, Lower End.
DD — 28 - Crack on Left Side; Accidental.
ZZ — 8-10-14 - Failure, Lower End.
B — 17- Hole near Bottom.
C — 11, 14 - One Hole.
C — 13 - Two Holes.
E — 25- One Hole.
E — 27- Three Holes.
V — 29- Two ,, ; ½" x 2".
Z — 6, 7, 11- Failure.
AA — 25-30 incl. Failure.
AA* — 50-56 ,, ,, .
B — 35- Failure; Three Holes.
B — 37, 38- ,, ; Holes.
C — 20 - ,, ; One Hole.
C — 22 - ,, ; Two Holes.
E — 29-36 incl. Failure; Holes Lower End.
T — 37 - Failure; One Hole, ½" x 2".
T — 39- ,, ; ,, ,, , 3/4" Diam.
U — 41- ,, ; ,, Small Hole.
V — 39- ,, ; ,, Hole.
V — 40- Bullet Hole.
Z — 422, 423, 424 - Failure.
Y* — 7, 8, 9 - Failure; Lower End.

James H. Gibboney

Chairman Inspection Committee

Date of Inspection... November 6, 1919.

ROW No. 1

DESIGNATION		CONDITION OF RUST																										
		Texture									Color									Adherence								
Mark	Sheet No.	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc.Adam 6	Mc.Donnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc.Adam 6	Mc.Donnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc.Adam 6	Mc.Donnell 7	Smith 8	Wheaton 9
AA	1	C	VC			VC	C	C	C	M	L	L			L	L	L	L	M	L	L			L	L	L	L	T
	2	C	VC			VC	C	C	C	M	L	L			L	L	L	L	M	L	L			L	L	L	L	T
	3	C	VC			VC	C	C	C	M	L	L			L	L	L	L	M	L	L			L	L	L	L	T
BB	1	M	S			M	S	M	M	M	M	M			L	M	M	M	D	T	T			L	T	T	L	T
	2	M	S			M	S	M	M	M	M	M			L	M	M	M	D	T	T			L	T	T	L	T
	3	M	S			M	S	M	M	M	M	M			L	M	M	M	D	T	T			L	T	T	L	T
CC	1	C	C			C	M	M	C	C	L	L			L	L	M	L	L	T	L			L	L	T	L	T
	3	C	C			C	M	M	C	C	L	L			L	L	M	L	L	T	L			L	L	T	L	T
	4	C	C			C	M	M	C	C	L	L			L	L	M	L	L	T	L			L	L	T	L	T
DD	1	M	M			C	M	M	C	C	M	L			L	L	L	L	M	T	L			T	L	T	L	T
	2	M	M			C	M	M	C	C	M	L			L	L	L	L	M	T	L			T	L	T	L	T
	3	M	M			C	M	M	C	C	M	L			L	L	L	L	M	T	L			T	L	T	L	T
EE*	1	S	M			M	M	M	M	M	M	M			M	M	L	M	M	T	T			T	T	T	L	T
	2	S	M			M	M	M	M	M	M	M			M	M	L	M	M	T	T			T	T	T	L	T
	3	S	M			M	M	M	M	M	M	M			M	M	L	M	M	T	T			T	T	T	L	T
HH	1	M	S			M	M	M	M	M	M	M			M	M	D	M	D	T	T			T	T	T	L	T
	2	M	S			M	M	M	M	M	M	M			M	M	D	M	D	T	T			T	T	T	L	T
	3	M	S			M	M	M	M	M	M	M			M	M	D	M	D	T	T			T	T	T	L	T
II	1	M	VS			S	S	S	S	S	M	D			D	D	D	D	D	T	T			T	T	T	T	T
	2	M	VS			S	S	S	S	S	M	D			D	D	D	D	D	T	T			T	T	T	T	T
	3	M	VS			S	S	S	S	S	M	D			D	D	D	D	D	T	T			T	T	T	T	T
KK	1	M	VS			S	S	S	M	S	M	D			D	D	D	D	D	T	T			T	T	T	L	T
	2	M	VS			S	S	S	M	S	M	D			D	D	D	D	D	T	T			T	T	T	L	T
	3	M	VS			S	S	S	M	S	M	D			D	D	D	D	D	T	T			T	T	T	L	T
MM*	1	M	M			M	M	S	M	M	M	M			M	M	D	M	D	T	L			T	L	T	L	T
	2	M	M			M	M	S	M	M	M	M			M	M	D	M	D	T	L			T	L	T	L	T
	3	M	M			M	M	S	M	M	M	M			M	M	D	M	D	T	L			T	L	T	L	T
SS	1	C	VC			VC	C	C	C	C	L	L			L	L	L	L	L	L	L			L	L	L	L	T
	2	C	VC			VC	C	C	C	C	L	L			L	L	L	L	L	L	L			L	L	L	L	T
	3	C	VC			VC	C	C	C	C	L	L			L	L	L	L	L	L	L			L	L	L	L	T
TT	1	M	S			S	S	S	M	M	M	D			M	M	D	M	M	T	T			T	T	T	T	T
	2	M	S			S	S	S	M	M	M	D			M	M	D	M	M	T	T			T	T	T	T	T
	3	M	S			S	S	S	M	M	M	D			M	M	D	M	M	T	T			T	T	T	T	T
UU	1	M	M			M	M	M	M	C	M	M			M	M	D	M	M	T	T			T	T	T	T	T
	2	M	M			M	M	M	M	C	M	M			M	M	D	M	M	T	T			T	T	T	T	T
	3	M	M			M	M	M	M	C	M	M			M	M	D	M	M	T	T			T	T	T	T	T
VV	1	M	M			M	M	M	M	C	M	M			M	M	M	M	M	T	T			T	T	T	L	T
	2	M	M			M	M	M	M	C	M	M			M	M	M	M	M	T	T			T	T	T	L	T
	3	M	M			M	M	M	M	C	M	M			M	M	M	M	M	T	T			T	T	T	L	T
XX	1	C	C			C	M	M	C	M	M	M			M	M	L	L	M	L	L			L	T	T	L	T
	2	C	C			C	M	M	C	M	M	M			M	M	L	L	M	L	L			L	T	T	L	T
	3	C	C			C	M	M	C	M	M	M			M	M	L	L	M	L	L			L	T	T	L	T
OO	1	M	C			M	M	M	M	M	M	M			M	D	D	M	M	T	L			T	T	T	L	T
	2	M	C			M	M	M	M	M	M	M			M	D	D	M	M	T	L			T	T	T	L	T
	3	M	C			M	M	M	M	M	M	M			M	D	D	M	M	T	L			T	T	T	L	T
OOO†	25	M	C			M	S	M	M	C	M	L			M	M	D	M	M	T	L			T	T	T	L	T
	26	M	C			M	S	M	M	C	M	L			M	M	D	M	M	T	L			T	T	T	L	T
	27	M	C			M	S	M	M	C	M	L			M	M	D	M	M	T	L			T	T	T	L	T

* Open Annealed.
† Exposed 11-[illegible]-18.

ROW No. 2

DESIGNATION		CONDITION OF RUST																										
		Texture									Color									Adherence								
Mark	Sheet No.	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc.Adam 6	Mc.Donnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc.Adam 6	Mc.Donnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc.Adam 6	Mc.Donnell 7	Smith 8	Wheaton 9
A	1	C	C			C	M	M	M	M	M	L			L	L	L	M	M	L	L			T	L	T	T	T
	2	C	C			C	M	M	M	M	M	L			L	L	L	M	M	L	L			T	L	T	T	T
	3	C	C			C	M	M	M	M	M	L			L	L	L	M	M	L	L			T	L	T	T	T
B	1	M	S			M	M	M	M	C	M	M			L	L	M	M	M	T	T			T	L	T	T	T
	2	M	S			M	M	M	M	C	M	M			L	L	M	M	M	T	T			T	L	T	T	T
	3	M	S			M	M	M	M	C	M	M			L	L	M	M	M	T	T			T	L	T	T	T
C	1	M	M			M	M	M	C	C	M	L			L	L	L	M	L	T	L			T	L	T	L	T
	2	M	M			M	M	M	C	C	M	L			L	L	L	M	L	T	L			T	L	T	L	T
	3	M	M			M	M	M	C	C	M	L			L	L	L	M	L	T	L			T	L	T	L	T
D	1	M	C			C	M	M	C	C	M	L			L	L	L	L	L	T	L			L	L	T	L	T
	5	M	C			C	M	M	C	C	M	L			L	L	L	L	L	T	L			L	L	T	L	T
	7	M	C			C	M	M	C	C	M	L			L	L	L	L	L	T	L			L	L	T	L	T
E	1	S	M			S	S	S	M	M	M	D			M	D	M	M	M	T	T			T	T	T	L	T
	2	S	M			S	S	S	M	M	M	D			M	D	M	M	M	T	T			T	T	T	L	T
	3	S	M			S	S	S	M	M	M	D			M	D	M	M	M	T	T			T	T	T	L	T
H	1	S	S			M	S	S	M	M	M	D			M	D		M	M	T	T			T	T	T	L	T
	2	S	S			M	S	S	M	M	M	D			M	D		M	M	T	T			T	T	T	L	T
	3	S	S			M	S	S	M	M	M	D			M	D		M	M	T	T			T	T	T	L	T
I	1	S	VS			VS	S	S	M	S	D	D			D	D	D	D	D	T	T			T		T	L	T
	2	S	VS			VS	S	S	M	S	D	D			D	D	D	D	D	T	T			T		T	L	T
	3	S	VS			VS	S	S	M	S	D	D			D	D	D	D	D	T	T			T		T	L	T
K	1	S	VS			S	S	S	M	M	D	D			M	D	D	M	D	T	T			T		T	T	T
	2	S	VS			S	S	S	M	M	D	D			M	D	D	M	D	T	T			T		T	T	T
	3	S	VS			S	S	S	M	M	D	D			M	D	D	M	D	T	T			T		T	T	T
M	1	M	M			M	S	M	M	C	M	M			M	D	D	M	D	T	L			T		T	L	T
	2	M	M			M	S	M	M	C	M	M			M	D	D	M	D	T	L			T		T	L	T
	3	M	M			M	S	M	M	C	M	M			M	D	D	M	D	T	L			T		T	L	T
S	1	C	VC			C	M	M	C	VC	M	L			L	L	L	L	L	T	L			T	L	T	L	T
	2	C	VC			C	M	M	C	VC	M	L			L	L	L	L	L	T	L			T	L	T	L	T
	3	C	VC			C	M	M	C	VC	M	L			L	L	L	L	L	T	L			T	L	T	L	T
T	1	S	S			M	M	M	M	M	D	D			M	M	D	M	D	T	T			T	T	T	T	T
	2	S	S			M	M	M	M	M	D	D			M	M	D	M	D	T	T			T	T	T	T	T
	3	S	S			M	M	M	M	M	D	D			M	M	D	M	D	T	T			T	T	T	T	T
U	1	M	M			M	M	M	C	C	M	M			M	M	D	M	M	L	L			T	T	T	L	T
	2	M	M			M	M	M	C	C	M	M			M	M	D	M	M	L	L			T	T	T	L	T
	3	M	M			M	M	M	C	C	M	M			M	M	D	M	M	L	L			T	T	T	L	T
V	1	M	M			M	S	M	C	C	M	M			M	M	D	L	M	L	L			T	T	T	L	T
	2	M	M			M	S	M	C	C	M	M			M	M	D	L	M	L	L			T	T	T	L	T
	3	M	M			M	S	M	C	C	M	M			M	M	D	L	M	L	L			T	T	T	L	T
X	1	C	C			C	C	M	C	VC	L	M			L	M	L	L	M	L	L			L	T	T	L	T
	2	C	C			C	C	M	C	VC	L	M			L	M	L	L	M	L	L			L	T	T	L	T
	3	C	C			C	C	M	C	VC	L	M			L	M	L	L	M	L	L			L	T	T	L	T
O	1	M	VC			C	M	C	C	VC	M	M			M	M	D	L	M	T	L			L	T	L	L	T
	2	M	VC			C	M	C	C	VC	M	M			M	M	D	L	M	T	L			L	T	L	L	T
	3	M	VC			C	M	C	C	VC	M	M			M	M	D	L	M	T	L			L	T	L	L	T
Z	1	S	C			C	M	C	C	VC	M	M			M	M	D	M	M	T	L			L	T	T	L	T
	2	S	C			C	M	C	C	VC	M	M			M	M	D	M	M	T	L			L	T	T	L	T
	3	S	C			C	M	C	C	VC	M	M			M	M	D	M	M	T	L			L	T	T	L	T

ROW No. 3

DESIGNATION		CONDITION OF RUST																										
		Texture									Color									Adherence								
Mark	Sheet No.	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc.Adam 6	Mc.Donnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc.Adam 6	Mc.Donnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc.Adam 6	Mc.Donnell 7	Smith 8	Wheaton 9
AA	4	C	VC			C	M	C	M	C	L	L			L	L	L	M	M	L	L			L	L	L	L	T
	5	C	VC			C	M	C	M	C	L	L			L	L	L	M	M	L	L			L	L	L	L	T
	6	C	VC			C	M	C	M	C	L	L			L	L	L	M	M	L	L			L	L	L	L	T
	7	C	VC			C	M	C	M	C	L	L			L	L	L	M	M	L	L			L	L	L	L	T
	8	C	VC			C	M	C	M	C	L	L			L	L	L	M	M	L	L			L	L	L	L	T
	9	C	VC			C	M	C	M	C	L	L			L	L	L	M	M	L	L			L	L	L	L	T
AA*	31	C	VC			C	M	C	M	C	L	M			L	M	L	M	M	L	L			L	T	L	L	T
	32	C	VC			C	M	C	M	C	L	M			L	M	L	M	M	L	L			L	T	L	L	T
	33	C	VC			C	M	C	M	C	L	M			L	M	L	M	M	L	L			L	T	L	L	T
	34	C	VC			C	M	C	M	C	L	M			L	M	L	M	M	L	L			L	T	L	L	T
	35	C	VC			C	M	C	M	C	L	M			L	M	L	M	M	L	L			L	T	L	L	T
	36	C	VC			C	M	C	M	C	L	M			L	M	L	M	M	L	L			L	T	L	L	T
	37	C	VC			C	M	C	M	C	L	M			L	M	L	M	M	L	L			L	T	L	L	T
	38	C	VC			C	M	C	M	C	L	M			L	M	L	M	M	L	L			L	T	L	L	T
	39	C	VC			C	M	C	M	C	L	M			L	M	L	M	M	L	L			L	T	L	L	T
BB	10	M	M			M	M	M	M	M	M	D			M	M	M	M	D	T	T			T	T	T	T	T
	11	M	M			M	M	M	M	M	M	D			M	M	M	M	D	T	T			T	T	T	T	T
	12	M	M			M	M	M	M	M	M	D			M	M	M	M	D	T	T			T	T	T	T	T
	13	M	M			M	M	M	M	M	M	D			M	M	M	M	D	T	T			T	T	T	T	T
	14	M	M			M	M	M	M	M	M	D			M	M	M	M	D	T	T			T	T	T	T	T
	37	M	M			M	M	M	M	M	M	D			M	M	M	M	D	T	T			T	T	T	T	T
BB*	25	M	M			M	M	M	S	S	M	M			D	M	M	M	D	T	L			T	T	T	T	T
	26	M	M			M	M	M	S	S	M	M			D	M	M	M	D	T	L			T	T	T	T	T
	27	M	M			M	M	M	S	S	M	M			D	M	M	M	D	T	L			T	T	T	T	T
	28	M	M			M	M	M	S	S	M	M			D	M	M	M	D	T	L			T	T	T	T	T
	42	M	S			S	M	M	S	S	D	D			D	M	D	D	D	T	L			T	T	T	T	T
	43	M	S			S	M	M	S	S	D	D			D	M	D	D	D	T	L			T	T	T	T	T
	44	M	S			S	M	M	S	S	D	D			D	M	D	D	D	T	L			T	T	T	T	T
	45	M	S			S	M	M	S	S	D	D			D	M	D	D	D	T	L			T	T	T	T	T
CC	5	C	C			C	M	C	M	C	M	L			M	L	L	L	L	L	L			L	L	T	L	T
	6	C	C			C	M	C	M	C	M	L			M	L	L	L	L	L	L			L	L	T	L	T
	8	C	C			C	M	C	M	C	M	L			M	L	L	L	L	L	L			L	L	T	L	T
CC*	20	C	C			C	M	M	C	M	M	M			M	M	M	M	M	T	L			L	T	T	L	T
	21	C	C			C	M	M	C	M	M	M			M	M	M	M	M	T	L			L	T	T	L	T
	22	C	C			C	M	M	C	M	M	M			M	M	M	M	M	T	L			L	T	T	L	T
	23	C	C			C	M	M	C	M	M	M			M	M	M	M	M	T	L			L	T	T	L	T
	24	C	C			C	M	M	C	M	M	M			M	M	M	M	M	T	L			L	T	T	L	T
	25	C	C			C	M	M	C	M	M	M			M	M	M	M	M	T	L			L	T	T	L	T
DD	4	M	C			M	M	M	M	M	M	M			L	M	M	M	M	T	L			L	T	T	L	T
	11	M	C			M	M	M	M	M	M	M			L	M	M	M	M	T	L			L	T	T	L	T
	12	M	C			M	M	M	M	M	M	M			L	M	M	M	M	T	L			L	T	T	L	T
	13	M	C			M	M	M	M	M	M	M			L	M	M	M	M	T	L			L	T	T	L	T
	14	M	C			M	M	M	M	M	M	M			L	M	M	M	M	T	L			L	T	T	L	T
	15	M	C			M	M	M	M	M	M	M			L	M	M	M	M	T	L			L	T	T	L	T
DD*	32	M	M			M	M	M	M	S	M	M			L	M	M	M	M	T	L			L	T	T	L	T
	33	M	M			M	M	M	M	S	M	M			L	M	M	M	M	T	L			L	T	T	L	T
	34	M	M			M	M	M	M	S	M	M			L	M	M	M	M	T	L			L	T	T	L	T
	35	M	M			M	M	M	M	S	M	M			L	M	M	M	M	T	L			L	T	T	L	T
	36	M	M			M	M	M	M	S	M	M			L	M	M	M	M	T	L			L	T	T	L	T
	37	M	M			M	M	M	M	S	M	M			L	M	M	M	M	T	L			L	T	T	L	T
	38	M	M			M	M	M	M	S	M	M			L	M	M	M	M	T	L			L	T	T	L	T

* Sand Blasted.

ROW No. 4

DESIGNATION		CONDITION OF RUST										
		Texture										
Mark	Sheet No.	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc.Adam 6	Mc.Donnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2
DD*	41	C	M			M	M	M	M	M	M	M
	42	C	M			M	M	M	M	M	M	M
	43	C	M			M	M	M	M	M	M	M
EE†	4	M	S			M	M	M	M	M	M	M
	5	M	S			M	M	M	M	M	M	M
	6	M	S			M	M	M	M	M	M	M
EE*	19	M	S			S	M	M	M	S	D	D
	20	M	S			S	M	M	M	S	D	D
	21	M	S			S	M	M	M	S	D	D
	22	M	S			S	M	M	M	S	D	D
	23	M	S			S	M	M	M	S	D	D
	24	M	S			S	M	M	M	S	D	D
HH	4	M	M			M	M	M	M	M	D	M
	5	M	M			M	M	M	M	M	D	M
	6	M	M			M	M	M	M	M	D	M
	7	M	M			M	M	M	M	M	D	M
	8	M	M			M	M	M	M	M	D	M
	9	M	M			M	M	M	M	M	D	M
HH*	27	M	S			S	M	S	M	S	D	D
	28	M	S			S	M	S	M	S	D	D
	29	M	S			S	M	S	M	S	D	D
	30	M	S			S	M	S	M	S	D	D
	31	M	S			S	M	S	M	S	D	D
	32	M	S			S	M	S	M	S	D	D
	33	M	S			S	M	S	M	S	D	D
II	4	S	S			S	M	S	M	M	D	M
	5	S	S			S	M	S	M	M	D	M
	6	S	S			S	M	S	M	M	D	M
	7	S	S			S	M	S	M	M	D	M
	8	S	S			S	M	S	M	M	D	M
II*	30	S	VS			VS	M	S	S	S	D	D
	31	S	VS			VS	M	S	S	S	D	D
	32	S	VS			VS	M	S	S	S	D	D
	33	S	VS			VS	M	S	S	S	D	D
	34	S	VS			VS	M	S	S	S	D	D
	35	S	VS			VS	M	S	S	S	D	D
	36	S	VS			VS	M	S	S	S	D	D
	37	S	VS			VS	M	S	S	S	D	D
KK	9	M	S			M	M	S	M	M	M	
	10	M	S			M	M	S	M	M	M	
	11	M	S			M	M	S	M	M	M	
	12	M	S			M	M	S	M	M	M	
	12	M	S			M	M	S	M	M	M	
	14	M	S			M	M	S	M	M	M	
	15	M	S			M	M	S	M	M	M	
KK*	35	S	VS			S	M	S	S	S	D	
	36	S	VS			S	M	S	S	S	D	
	37	S	VS			S	M	S	S	S	D	
	38	S	VS			S	M	S	S	S	D	
	39	S	VS			S	M	S	S	S	D	
	40	S	VS			S	M	S	S	S	D	

* Sand Blasted.
† Open Annealed.

CONDITION OF RUST.

Texture	Color	Adherence
VS—Very Smooth	L—Light	T—Tight
S—Smooth	M—Medium	L—Loose
M—Medium	D—Dark	
C—Coarse		
VC—Very Coarse		

— INSPECTION COMMITTEE —

J. H. Gibboney, Chairman — Norfolk & Western Ry. Co.
J. A. Aupperle — American Rolling Mill Co.
D. M. Buck — American Sheet & Tin Plate Co.
W. A. Cooper — Alan Wood Iron & Steel Co.
W. R. Fleming — The Andrews Steel Co.
D. J. Mc. Adam, Jr. — U. S. Navy, Bureau Steam Engineering.
M. E. Mc. Donnell — Pennsylvania Railroad Co.
H. E. Smith — New York Central Railroad Co.
F. B. Wheaton — U. S. Army, Quartermaster's Corps.

NOTES:

Gibboney — None.
Aupperle — CCC* Sheets 28-35 incl. not as good as Sheets A-
Buck — "
Cooper — Did not make Inspection.
Fleming — " " " "
Mc. Adam — None.
Mc. Donnell — " .
Smith — " .
Wheaton — " .

Table II.—Results of Inspection of Corrosion Test Sheets, at Annapolis, Md., November 6, 1919.

AMERICAN SOCIETY FOR TESTING MATERIALS
COMMITTEE A-5 ON CORROSION OF IRON AND STEEL
TESTS OF UNCOATED SHEETS
ANNAPOLIS, MARYLAND

EXPOSED OCTOBER 17, 1916

1919.

6 Mc.Adam	7 Mc.Donnell	8 Smith	9 Wheaton
L	L	L	T
L	L	L	T
L	L	L	T.
L	L	L	T
L	L	L	T
L	L	L	T
T	L	L	T
T	L	L	T
T	L	L	T
T	L	L	T
T	L	L	T
T	L	L	T
T	L	L	T
T	L	L	T
T	L	L	T
T	T	T	T
T	T	T	T
T	T	T	T
T	T	T	T
T	T	T	T
T	T	T	T
T	T	T	T
T	T	T	T
T	T	T	T
T	T	T	T
T	T	T	T
T	T	T	T
T	T	T	T
T	T	T	T
L	T	L	T
L	T	L	T
L	T	L	T
T	T	L	T
T	T	L	T
T	T	L	T
T	T	L	T
T	T	L	T
T	T	L	T
T	T	L	T
T	T	L	T
T	T	L	T
T	T	L	T
T	T	L	T
T	T	L	T
T	T	L	T
T	T	L	T
T	T	L	T
T	T	L	T
T	T	L	T
T	T	L	T
T	T	L	T

ROW No. 4

Designation: Mark	Sheet No.	Condition of Rust: Texture 1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 Mc.Adam	7 Mc.Donnell	8 Smith	9 Wheaton	Color 1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 Mc.Adam	7 Mc.Donnell	8 Smith	9 Wheaton	Adherence 1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 Mc.Adam	7 Mc.Donnell	8 Smith	9 Wheaton
DD§	41	C	M			M	M	M	M	M	M	M			L	L	L	L	L	T	L			T	L	T	L	T
	42	C	M			M	M	M	M	M	M	M			L	L	L	L	L	T	L			T	L	T	L	T
	43	C	M			M	M	M	M	M	M	M			L	L	L	L	L	T	L			T	L	T	L	T
EE†	4	M	S			M	M	M	M	M	M	M			M	L	L	L	M	T	T			T	L	T	T	T
	5	M	S			M	M	M	M	M	M	M			M	L	L	L	M	T	T			T	L	T	T	T
	6	M	S			M	M	M	M	M	M	M			M	L	L	L	M	T	T			T	L	T	T	T
EE§	19	M	S			S	M	M	M	S	D	D			M	M	M	M	M	T	T			T	L	T	T	T
	20	M	S			S	M	M	M	S	D	D			M	M	M	M	M	T	T			T	L	T	T	T
	21	M	S			S	M	M	M	S	D	D			M	M	M	M	M	T	T			T	L	T	T	T
	22	M	S			S	M	M	M	S	D	D			M	M	M	M	M	T	T			T	L	T	T	T
	23	M	S			S	M	M	M	S	D	D			M	M	M	M	M	T	T			T	L	T	T	T
	24	M	S			S	M	M	M	S	D	D			M	M	M	M	M	T	T			T	L	T	T	T
HH	4	M	M			M	M	M	M	M	D	M			M	M	D	M	L	T	T			T	L	T	L	T
	5	M	M			M	M	M	M	M	D	M			M	M	D	M	L	T	T			T	L	T	L	T
	6	M	M			M	M	M	M	M	D	M			M	M	D	M	L	T	T			T	L	T	L	T
	7	M	M			M	M	M	M	M	D	M			M	M	D	M	L	T	T			T	L	T	L	T
	8	M	M			M	M	M	M	M	D	M			M	M	D	M	L	T	T			T	L	T	L	T
	9	M	M			M	M	M	M	M	D	M			M	M	D	M	L	T	T			T	L	T	L	T
HH§	27	M	S			S	M	S	M	S	D	D			M	M	D	M	M	T	T			T	T	T	L	T
	28	M	S			S	M	S	M	S	D	D			M	M	D	M	M	T	T			T	T	T	L	T
	29	M	S			S	M	S	M	S	D	D			M	M	D	M	M	T	T			T	T	T	L	T
	30	M	S			S	M	S	M	S	D	D			M	M	D	M	M	T	T			T	T	T	L	T
	31	M	S			S	M	S	M	S	D	D			M	M	D	M	M	T	T			T	T	T	L	T
	32	M	S			S	M	S	M	S	D	D			M	M	D	M	M	T	T			T	T	T	L	T
	33	M	S			S	M	S	M	S	D	D			M	M	D	M	M	T	T			T	T	T	L	T
II	4	S	S			S	M	S	M	M	D	M			D	D	D	M	M	T	T			T	T	T	T	T
	5	S	S			S	M	S	M	M	D	M			D	D	D	M	M	T	T			T	T	T	T	T
	6	S	S			S	M	S	M	M	D	M			D	D	D	M	M	T	T			T	T	T	T	T
	7	S	S			S	M	S	M	M	D	M			D	D	D	M	M	T	T			T	T	T	T	T
	8	S	S			S	M	S	M	M	D	M			D	D	D	M	M	T	T			T	T	T	T	T
II§	30	S	VS			VS	M	S	S	S	D	D			D	D	D	M	D	T	T			T	T	T	T	T
	31	S	VS			VS	M	S	S	S	D	D			D	D	D	M	D	T	T			T	T	T	T	T
	32	S	VS			VS	M	S	S	S	D	D			D	D	D	M	D	T	T			T	T	T	T	T
	33	S	VS			VS	M	S	S	S	D	D			D	D	D	M	D	T	T			T	T	T	T	T
	34	S	VS			VS	M	S	S	S	D	D			D	D	D	M	D	T	T			T	T	T	T	T
	35	S	VS			VS	M	S	S	S	D	D			D	D	D	M	D	T	T			T	T	T	T	T
	36	S	VS			VS	M	S	S	S	D	D			D	D	D	M	D	T	T			T	T	T	T	T
	37	S	VS			VS	M	S	S	S	D	D			D	D	D	M	D	T	T			T	T	T	T	T
KK	9	M	S			M	M	S	M	M	M	M			M	D	M	M	M	T	T			T	T	T	T	T
	10	M	S			M	M	S	M	M	M	M			M	D	M	M	M	T	T			T	T	T	T	T
	11	M	S			M	M	S	M	M	M	M			M	D	M	M	M	T	T			T	T	T	T	T
	12	M	S			M	M	S	M	M	M	M			M	D	M	M	M	T	T			T	T	T	T	T
	12	M	S			M	M	S	M	M	M	M			M	D	M	M	M	T	T			T	T	T	T	T
	14	M	S			M	M	S	M	M	M	M			M	D	M	M	M	T	T			T	T	T	T	T
	15	M	S			M	M	S	M	M	M	M			M	D	M	M	M	T	T			T	T	T	T	T
KK§	35	S	VS			S	M	S	S	S	D	D			D	D	D	M	D	T	T			T	T	T	T	T
	36	S	VS			S	M	S	S	S	D	D			D	D	D	M	D	T	T			T	T	T	T	T
	37	S	VS			S	M	S	S	S	D	D			D	D	D	M	D	T	T			T	T	T	T	T
	38	S	VS			S	M	S	S	S	D	D			D	D	D	M	D	T	T			T	T	T	T	T
	39	S	VS			S	M	S	S	S	D	D			D	D	D	M	D	T	T			T	T	T	T	T
	40	S	VS			S	M	S	S	S	D	D			D	D	D	M	D	T	T			T	T	T	T	T

§ [illegible] Sheeted.
† Open Annealed.

ROW No. 5

Designation: Mark	Sheet No.	Condition of Rust: Texture 1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 Mc.Adam	7 Mc.Donnell	8 Smith	9 Wheaton	Color 1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 Mc.Adam	7 Mc.Donnell	8 Smith	9 Wheaton	Adherence 1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 Mc.Adam	7 Mc.Donnell	8 Smith	9 Wheaton
KK§	41	VS	VS			S	M	VS	S	VS	D	D			D	D	D	D	D	T	T			T	T	T	T	T
	42	VS	VS			S	M	VS	S	VS	D	D			D	D	D	D	D	T	T			T	T	T	T	T
MM†	4	M	M			M	M	M	M	M	M	M			M	M	M	M	M	T	T			T	T	T	L	T
	5	M	M			M	M	M	M	M	M	M			M	M	M	M	M	T	T			T	T	T	L	T
	6	M	M			M	M	M	M	M	M	M			M	M	M	M	M	T	T			T	T	T	L	T
	7	M	M			M	M	M	M	M	M	M			M	M	M	M	M	T	T			T	T	T	L	T
	8	M	M			M	M	M	M	M	M	M			M	M	M	M	M	T	T			T	T	T	L	T
	9	M	M			M	M	M	M	M	M	M			M	M	M	M	M	T	T			T	T	T	L	T
	10	M	M			M	M	M	M	M	M	M			M	M	M	M	M	T	T			T	T	T	L	T
	11	M	M			M	M	M	M	M	M	M			M	M	M	M	M	T	T			T	T	T	L	T
	12	M	M			M	M	M	M	M	M	M			M	M	M	M	M	T	T			T	T	T	L	T
	13	M	M			M	M	M	M	M	M	M			M	M	M	M	M	T	T			T	T	T	L	T
	14	M	M			M	M	M	M	M	M	M			M	M	M	M	M	T	T			T	T	T	L	T
SS	4	C	VC			VC	M	C	C	C	L	L			L	L	L	L	L	L	L			L	L	T	L	T
	5	C	VC			VC	M	C	C	C	L	L			L	L	L	L	L	L	L			L	L	T	L	T
	6	C	VC			VC	M	C	C	C	L	L			L	L	L	L	L	L	L			L	L	T	L	T
	7	C	VC			VC	M	C	C	C	L	L			L	L	L	L	L	L	L			L	L	T	L	T
	8	C	VC			VC	M	C	C	C	L	L			L	L	L	L	L	L	L			L	L	T	L	T
	9	C	VC			VC	M	C	C	C	L	L			L	L	L	L	L	L	L			L	L	T	L	T
	10	C	VC			VC	M	C	C	C	L	L			L	L	L	L	L	L	L			L	L	T	L	T
	11	C	VC			VC	M	C	C	C	L	L			L	L	L	L	L	L	L			L	L	T	L	T
	12	C	VC			VC	M	C	C	C	L	L			L	L	L	L	L	L	L			L	L	T	L	T
	13	C	VC			VC	M	C	C	C	L	L			L	L	L	L	L	L	L			L	L	T	L	T
	14	C	VC			VC	M	C	C	C	L	L			L	L	L	L	L	L	L			L	L	T	L	T
TT	4	M	S			S	M	S	M	M	M	M			M	L	D	M	M	T	T			T	T	T	L	T
	5	M	S			S	M	S	M	M	M	M			M	D	D	M	M	T	T			T	T	T	L	T
	6	M	S			S	M	S	M	M	M	M			M	D	D	M	M	T	T			T	T	T	L	T
	7	M	S			S	M	S	M	M	M	M			M	D	D	M	M	T	T			T	T	T	L	T
	8	M	S			S	M	S	M	VS	M	M			M	D	D	M	M	T	T			T	T	T	L	T
	9	M	S			S	M	S	M	M	M	M			M	D	D	M	M	T	T			T	T	T	L	T
	10	M	S			S	M	S	M	M	M	M			M	D	D	M	M	T	T			T	T	T	L	T
	11	M	S			S	M	S	M	M	M	M			M	D	D	M	M	T	T			T	T	T	L	T
	12	M	S			S	M	S	M	M	M	M			M	D	D	M	M	T	T			T	T	T	L	T
	13	M	S			S	M	S	M	M	M	M			M	D	D	M	M	T	T			T	T	T	L	T
	14	M	S			S	M	S	M	M	M	M			M	D	D	M	M	T	T			T	T	T	L	T
UU	4	M	M			M	M	M	M	M	M	M			D	M	D	M	M	T	T			T	T	T	L	T
	5	M	M			M	M	M	M	M	M	M			D	M	D	M	M	T	T			T	T	T	L	T
	6	M	M			M	M	M	M	M	M	M			D	M	D	M	M	T	T			T	T	T	L	T
	7	M	M			M	M	M	M	M	M	M			D	M	D	M	M	T	T			T	T	T	L	T
	8	M	M			M	M	M	M	M	M	M			D	M	D	M	M	T	T			T	T	T	L	T
	9	M	M			M	M	M	M	M	M	M			D	M	D	M	M	T	T			T	T	T	L	T
	10	M	M			M	M	M	M	M	M	M			D	M	D	M	M	T	T			T	T	T	L	T
	11	M	M			M	M	M	M	M	M	M			D	M	D	M	M	T	T			T	T	T	L	T
	12	M	M			M	M	M	M	M	M	M			D	M	D	M	M	T	T			T	T	T	L	T
	13	M	M			M	M	M	M	M	M	M			D	M	D	M	M	T	T			T	T	T	L	T
	14	M	M			M	M	M	M	M	M	M			D	M	D	M	M	T	T			T	T	T	L	T
VV	4	M	M			M	M	C	M	C	M	M			M	M	D	M	M	T	L			T	T	L	L	T
	5	M	M			M	M	C	M	C	M	M			M	M	D	M	M	T	L			T	T	L	L	T
	6	M	M			M	M	C	M	C	M	M			M	M	D	M	M	T	L			T	T	L	L	T

§ [illegible] Sheeted.
† Open Annealed.

ROW No. 6

Designation: Mark	Sheet No.	Condition of Rust: Texture 1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 Mc.Adam	7 Mc.Donnell	8 Smith	9 Wheaton	Color 1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 Mc.Adam	7 Mc.Donnell	8 Smith	9 Wheaton	Adherence 1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 Mc.Adam	7 Mc.Donnell	8 Smith	9 Wheaton
VV	7	M	M			M	M	M	M	C	M	L			M	L	L	M	L	L	L			L	L	T	L	T
	8	M	M			M	M	M	M	C	M	L			M	L	L	M	L	L	L			L	L	T	L	T
	9	M	M			M	M	M	M	C	M	L			M	L	L	M	L	L	L			L	L	T	L	T
	10	M	M			M	M	M	M	C	M	L			M	L	L	M	L	L	L			L	L	T	L	T
	11	M	M			M	M	M	M	C	M	L			M	L	L	M	L	L	L			L	L	T	L	T
	12	M	M			M	M	M	M	C	M	L			M	L	L	M	L	L	L			L	L	T	L	T
	13	M	M			M	M	M	M	C	M	L			M	L	L	M	L	L	L			L	L	T	L	T
	14	M	M			M	M	M	M	C	M	L			M	L	L	M	L	L	L			L	L	T	L	T
XX	4	C	C			C	M	C	C	C	L	L			L	L	L	M	L	L	L			L	L	L	L	T
	5	C	C			C	M	C	C	C	L	L			L	L	L	M	L	L	L			L	L	L	L	T
	6	C	C			C	M	C	C	C	L	L			L	L	L	M	L	L	L			L	L	L	L	T
	7	C	C			C	M	C	C	C	L	L			L	L	L	M	L	L	L			L	L	L	L	T
	8	C	C			C	M	C	C	C	L	L			L	L	L	M	L	L	L			L	L	L	L	T
	9	C	C			C	M	C	C	C	L	L			L	L	L	M	L	L	L			L	L	L	L	T
	10	C	C			C	M	C	C	C	L	L			L	L	L	M	L	L	L			L	L	L	L	T
	11	C	C			C	M	C	C	C	L	L			L	L	L	M	L	L	L			L	L	L	L	T
	12	C	C			C	M	C	C	C	L	L			L	L	L	M	L	L	L			L	L	L	L	T
	13	C	C			C	M	C	C	C	L	L			L	L	L	M	L	L	L			L	L	L	L	T
	14	C	C			C	M	C	C	C	L	L			L	L	L	M	L	L	L			L	L	L	L	T
ZZ	1	C	C			C	M	C	M	M	L	M			L	L	L	L	M	L	L			L	L	T	L	T
	2	C	C			C	M	C	M	M	L	M			L	L	L	L	M	L	L			L	L	T	L	T
	4	C	C			C	M	C	M	C	L	M			L	L	L	L	M	L	L			L	L	T	L	T
	307	M	S			M	M	S	M	S	M	D			M	M	D	M	M	T	T			T	T	T	L	T
	501	M	S			M	M	S	M	M	M	D			M	M	D	M	M	T	T			T	T	T	L	T
	502	M	S			M	M	S	M	M	M	D			M	M	D	M	M	T	T			T	T	T	L	T
	503	M	S			M	M	S	M	M	M	D			M	M	D	M	M	T	T			T	T	T	L	T
	201	M	S			M	M	S	M	S	M	D			M	M	D	M	M	T	T			T	T	T	L	T
	202	M	S			M	M	S	M	S	M	D			M	M	D	M	M	T	T			T	T	T	L	T
	204	M	S			M	M	S	M	S	M	D			M	M	D	M	M	T	T			T	T	T	L	T
	306	S	VS			M	M	S	M	S	D	D			M	M	D	M	M	T	T			T	T	T	L	T
	602	S	VS			S	M	S	M	S	D	D			M	M	D	M	M	T	T			T	T	T	L	T
	605	S	VS			S	M	S	M	S	D	D			M	M	D	M	M	T	T			T	T	T	L	T
	710	S	VS			S	M	VS	M	S	D	D			M	M	D	M	M	T	T			T	T	T	L	T
	711	S	VS			S	M	S	M	M	D	D			M	M	D	M	M	T	T			T	T	T	L	T
	102	S	VS			S	M	S	M	S	D	D			M	M	D	M	M	T	T			T	T	T	L	T
	103	S	VS			S	M	S	M	S	D	D			M	M	D	M	M	T	T			T	T	T	L	T
	417	C	M			S	M	S	M	M	M	M			M	M	D	M	M	T	L			T	T	T	L	T
	418	C	M			S	M	S	M	M	M	M			M	M	D	M	M	T	L			T	T	T	L	T
	419	C	M			S	M	S	M	M	M	M			M	M	D	M	M	T	L			T	T	T	L	T
OO	4	C	C			C	M	M	C	C	M	L			M	M	D	M	M	L	L			L	T	T	L	T
	5	C	C			C	M	M	C	C	M	L			M	M	D	M	M	L	L			L	T	T	L	T
	6	C	C			C	M	M	C	C	M	L			M	M	D	M	M	L	L			L	T	T	L	T
	7	C	C			C	M	M	C	C	M	L			M	M	D	M	M	L	L			L	T	T	L	T
	8	C	C			C	M	M	C	C	M	L			M	M	D	M	M	L	L			L	T	T	L	T
	9	C	C			C	M	M	C	C	M	L			M	M	D	M	M	L	L			L	T	T	L	T
	10	C	C			C	M	M	C	C	M	L			M	M	D	M	M	L	L			L	T	T	L	T
	11	C	C			C	M	M	C	C	M	L			M	M	D	M	M	L	L			L	T	T	L	T
	12	C	C			C	M	M	C	C	M	L			M	M	D	M	M	L	L			L	T	T	L	T

ROW No. 7

Designation: Mark	Sheet No.	Condition of Rust: Texture 1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 Mc.Adam	7 Mc.Donnell	8 Smith	9 Wheaton	Color 1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 Mc.Adam
OO‡	28	C	C			C	M	C	M	C	L	L			M	L
	29	C	C			C	M	C	M	C	L	L			M	L
	30	C	C			C	M	C	M	C	L	L			M	L
	31	C	C			C	M	C	M	C	L	L			M	L
	32	C	C			C	M	C	M	C	L	L			M	L
	33	C	C			C	M	C	M	C	L	L			M	L
	34	C	C			C	M	C	M	C	L	L			M	L
	35	C	C			C	M	C	M	C	L	L			M	L
A	4	C	C			C	M	C	C	C	M	M			M	M
	5	C	C			C	M	C	C	C	M	M			M	M
	6	C	C			C	M	C	C	C	M	M			M	M
	7	C	C			C	M	C	C	C	M	M			M	M
	8	C	C			C	M	C	C	C	M	M			M	M
	9	C	C			C	M	C	C	C	M	M			M	M
	10	C	C			C	M	C	C	C	M	M			M	M
	11	C	C			C	M	C	C	C	M	M			M	M
	12	C	C			C	M	C	C	C	M	M			M	M
	13	C	C			C	M	C	C	C	M	M			M	M
	14	C	C			C	M	C	C	C	M	M			M	M
	15	C	C			C	M	C	C	C	M	M			M	M
B	4	M	M			C	M	M	C	M	M	M			M	M
	6	M	M			C	M	M	C	M	M	M			M	M
	7	M	M			C	M	M	C	M	M	M			M	M
	8	M	M			C	M	M	C	M	M	M			M	M
	24	M	M			M	M	M	C	M	M	M			M	M
	25	M	M			M	M	M	C	M	M	M			M	M
	26	M	M			M	M	M	C	M	M	M			M	M
	27	M	M			M	M	M	C	M	M	M			M	M
	28	M	M			M	M	M	C	M	M	M			M	M
C	4	C	C			M	M	M	C	C	M	L			M	L
	5	C	C			M	M	M	C	C	M	L			M	L
	15	C	C			M	M	M	C	C	M	L			M	L
	16	C	C			M	M	M	C	C	M	L			M	L
	17	C	C			M	M	M	C	C	M	L			M	L
	23	C	C			M	M	M	C	C	M	L			M	L
	24	C	C			M	M	M	C	C	M	L			M	L
	25	C	C			M	M	M	C	C	M	L			M	L
	26	C	C			M	M	M	C	C	M	L			M	L
D	8	C	C			C	M	C	C	C	M	L			L	L
	9	C	C			C	M	C	C	C	M	L			L	L
	12	C	C			C	M	C	C	C	M	L			L	L
	14	C	C			C	M	C	C	C	M	L			L	L
E	4	M	M			M	M	M	M	M	M	M			D	M
	5	M	M			M	M	M	M	M	M	M			D	M
	6	M	M			M	M	M	M	M	M	M			D	M
	7	M	M			M	M	M	M	M	M	M			D	M
	8	M	M			M	M	M	M	M	M	M			D	M
	9	M	M			M	M	M	M	M	M	M			D	M
	10	M	M			M	M	M	M	M	M	M			D	M
	11	M	M			M	M	M	M	M	M	M			D	M

‡ Exposed 11-29-18.

ets 28-35 incl. not as good as Sheets A- 4 to 15 incl.

ake Inspection.

” ”

PLATE II.
PROC. AM. SOC. TEST. MATS.
VOL. XX, PART I.
REPORT OF COMMITTEE A-5:
CORROSION TESTS.

Weather *Clear and Warm.*

CONDITION OF RUST

Color 3 Cooper	Color 4 Fleming	Color 5 Gibboney	Color 6 Mc.Adam	Color 7 Mc.Donnell	Color 8 Smith	Color 9 Wheaton	Adherence 1 Aupperle	Adherence 2 Buck	Adherence 3 Cooper	Adherence 4 Fleming	Adherence 5 Gibboney	Adherence 6 Mc.Adam	Adherence 7 Mc.Donnell	Adherence 8 Smith	Adherence 9 Wheaton
		M	L	L	M	M	T	L			T	L	T	L	T
		M	L	L	M	M	T	L			T	L	T	L	T
		M	L	L	M	M	T	L			T	L	T	L	T
		M	L	L	M	M	T	L			T	L	T	L	T
		M	L	L	M	M	T	L			T	L	T	L	T
		M	L	L	M	M	T	L			T	L	T	L	T
		M	L	L	M	M	T	L			T	L	T	L	T
		M	L	L	M	M	T	L			T	L	T	L	T
		M	M	L	M	D	T	L			T	T	T	L	T
		M	M	L	M	D	T	L			T	T	T	L	T
		M	M	L	M	D	T	L			T	T	T	L	T
		M	M	L	M	D	T	L			T	T	T	L	T
		M	M	L	M	D	T	L			T	T	T	L	T
		M	M	L	M	D	T	L			T	T	T	L	T
		M	M	L	M	D	T	L			T	T	T	L	T
		M	M	L	M	D	T	L			T	T	T	L	T
		M	M	L	M	D	T	L			T	T	T	L	T
		M	M	L	M	D	T	L			T	T	T	L	T
		M	M	L	M	D	T	L			T	T	T	L	T
		M	M	L	M	D	T	L			T	T	T	L	T
		M	M	M	M	D	T	T			T	T	T	L	T
		M	M	M	M	D	T	T			T	T	T	L	T
		M	M	M	M	D	T	T			T	T	T	L	T
		M	M	M	M	D	T	T			T	T	T	L	T
		M	M	M	M	D	T	T			T	T	T	L	T
		M	M	M	M	D	T	T			T	T	T	L	T
		M	M	M	M	D	T	T			T	T	T	L	T
		M	M	M	M	D	T	T			T	T	T	L	T
		M	M	M	M	D	T	T			T	T	T	L	T
		M	L	M	L	L	L	L			L	L	T	L	T
		M	L	M	L	L	L	L			L	L	T	L	T
		M	L	M	L	L	L	L			L	L	T	L	T
		M	L	M	L	L	L	L			L	L	T	L	T
		M	L	M	L	L	L	L			L	L	T	L	T
		M	L	M	L	L	L	L			L	L	T	L	T
		M	L	M	L	L	L	L			L	L	T	L	T
		M	L	M	L	L	L	L			L	L	T	L	T
		M	L	M	L	L	L	L			L	L	T	L	T
		L	L	M	L	L	L	L			L	L	T	L	T
		L	L	M	L	L	L	L			L	L	T	L	T
		L	L	M	L	L	L	L			L	L	T	L	T
		L	L	M	L	L	L	L			L	L	T	L	T
		D	M	D	M	M	T	L			T	T	T	L	T
		D	M	D	M	M	T	L			T	T	T	L	T
		D	M	D	M	M	T	L			T	T	T	L	T
		D	M	D	M	M	T	L			T	T	T	L	T
		D	M	D	M	M	T	L			T	T	T	L	T
		D	M	D	M	M	T	L			T	T	T	L	T
		D	M	D	M	M	T	L			T	T	T	L	T
		D	M	D	M	M	T	L			T	T	T	L	T

ROW No. 8

Designation Mark	Designation Sheet No.	Texture 1 Aupperle	Texture 2 Buck	Texture 3 Cooper	Texture 4 Fleming	Texture 5 Gibboney	Texture 6 Mc.Adam	Texture 7 Mc.Donnell	Texture 8 Smith	Texture 9 Wheaton	Color 1 Aupperle	Color 2 Buck	Color 3 Cooper	Color 4 Fleming	Color 5 Gibboney	Color 6 Mc.Adam	Color 7 Mc.Donnell	Color 8 Smith	Color 9 Wheaton	Adherence 1 Aupperle	Adherence 2 Buck	Adherence 3 Cooper	Adherence 4 Fleming	Adherence 5 Gibboney	Adherence 6 Mc.Adam	Adherence 7 Mc.Donnell	Adherence 8 Smith	Adherence 9 Wheaton
H	4	M	S			S	M	S	M	C	M	M			M	L	D	M	M	T	T			T	L	T	L	T
	5	M	S			S	M	S	M	C	M	M			M	L	D	M	M	T	T			T	L	T	L	T
	6	M	S			S	M	S	M	C	M	M			M	L	D	M	M	T	T			T	L	T	L	T
	7	M	S			S	M	S	M	C	M	M			M	L	D	M	M	T	T			T	L	T	L	T
	8	M	S			S	M	S	M	C	M	M			M	L	D	M	M	T	T			T	L	T	L	T
	9	M	S			S	M	S	M	C	M	M			M	L	D	M	M	T	T			T	L	T	L	T
	10	M	S			S	M	S	M	C	M	M			M	L	D	M	M	T	T			T	L	T	L	T
	11	M	S			S	M	S	M	C	M	M			M	L	D	M	M	T	T			T	L	T	L	T
	12	M	S			S	M	S	M	C	M	M			M	L	D	M	M	T	T			T	L	T	L	T
	13	M	S			S	M	S	M	C	M	M			M	L	D	M	M	T	T			T	L	T	L	T
	14	M	S			S	M	S	M	C	M	M			M	L	D	M	M	T	T			T	L	T	L	T
	16	M	S			S	M	S	M	C	M	M			M	L	D	M	M	T	T			T	L	T	L	T
	18	M	S			S	M	S	M	C	M	M			M	L	D	M	M	T	T			T	L	T	L	T
I	4	S	VS			VS	M	VS	M	M	M	D			D	M	D	D	M	T	T			T	T	T	L	T
	5	S	VS			VS	M	VS	M	M	M	D			D	M	D	D	M	T	T			T	T	T	L	T
	6	S	VS			VS	M	VS	M	M	M	D			D	M	D	D	M	T	T			T	T	T	L	T
	7	S	VS			VS	M	VS	M	M	M	D			D	M	D	D	M	T	T			T	T	T	L	T
	8	S	VS			VS	M	VS	M	M	M	D			D	M	D	D	M	T	T			T	T	T	L	T
	9	S	VS			VS	M	VS	M	M	M	D			D	M	D	D	M	T	T			T	T	T	L	T
	10	S	VS			VS	M	VS	M	M	M	D			D	M	D	D	M	T	T			T	T	T	L	T
	11	S	VS			VS	M	VS	M	M	M	D			D	M	D	D	M	T	T			T	T	T	L	T
	12	S	VS			VS	M	VS	M	M	M	D			D	M	D	D	M	T	T			T	T	T	L	T
	13	S	VS			VS	M	VS	M	M	M	D			D	M	D	D	M	T	T			T	T	T	L	T
	14	S	VS			VS	M	VS	M	M	M	D			D	M	D	D	M	T	T			T	T	T	L	T
	15	S	VS			VS	M	VS	M	M	M	D			D	M	D	D	M	T	T			T	T	T	L	T
	16	S	VS			VS	M	VS	M	M	M	D			D	M	D	D	M	T	T			T	T	T	L	T
K	4	S	VS			S	M	S	M	M	D	D			D	M	D	M	M	T	T			T	T	T	L	T
	5	S	VS			S	M	S	M	M	D	D			D	M	D	M	M	T	T			T	T	T	L	T
	6	S	VS			S	M	S	M	M	D	D			D	M	D	M	M	T	T			T	T	T	L	T
	7	S	VS			S	M	S	M	M	D	D			D	M	D	M	M	T	T			T	T	T	L	T
	8	S	VS			S	M	S	M	M	D	D			D	M	D	M	M	T	T			T	T	T	L	T
	9	S	VS			S	M	S	M	M	D	D			D	M	D	M	M	T	T			T	T	T	L	T
	10	S	VS			S	M	S	M	M	D	D			D	M	D	M	M	T	T			T	T	T	L	T
	11	S	VS			S	M	S	M	M	D	D			D	M	D	M	M	T	T			T	T	T	L	T
	12	S	VS			S	M	S	M	M	D	D			D	M	D	M	M	T	T			T	T	T	L	T
	13	S	VS			S	M	S	M	M	D	D			D	M	D	M	M	T	T			T	T	T	L	T
	14	S	VS			S	M	S	M	M	D	D			D	M	D	M	M	T	T			T	T	T	L	T
	15	S	VS			S	M	S	M	M	D	D			D	M	D	M	M	T	T			T	T	T	L	T
	16	S	VS			S	M	S	M	M	D	D			D	M	D	M	M	T	T			T	T	T	L	T
M	4	M	M			M	M	M	C	C	M	M			M	M	M	M	M	T	T			T	T	T	L	T
	5	M	M			M	M	M	C	C	M	M			M	M	M	M	M	T	T			T	T	T	L	T
	6	M	M			M	M	M	C	C	M	M			M	M	M	M	M	T	T			T	T	T	L	T
	7	M	M			M	M	M	C	C	M	M			M	M	M	M	M	T	T			T	T	T	L	T
	8	M	M			M	M	M	C	C	M	M			M	M	M	M	M	T	T			T	T	T	L	T
	9	M	M			M	M	M	C	C	M	M			M	M	M	M	M	T	T			T	T	T	L	T
	10	M	M			M	M	M	C	C	M	M			M	M	M	M	M	T	T			T	T	T	L	T
	11	M	M			M	M	M	C	C	M	M			M	M	M	M	M	T	T			T	T	T	L	T
	12	M	M			M	M	M	C	C	M	M			M	M	M	M	M	T	T			T	T	T	L	T
	13	M	M			M	M	M	C	C	M	M			M	M	M	M	M	T	T			T	T	T	L	T
	14	M	M			M	M	M	C	C	M	M			M	M	M	M	M	T	T			T	T	T	L	T

ROW No. 9

Designation Mark	Designation Sheet No.	Texture 1 Aupperle	Texture 2 Buck	Texture 3 Cooper	Texture 4 Fleming	Texture 5 Gibboney	Texture 6 Mc.Adam	Texture 7 Mc.Donnell	Texture 8 Smith	Texture 9 Wheaton	Color 1 Aupperle	Color 2 Buck	Color 3 Cooper	Color 4 Fleming	Color 5 Gibboney	Color 6 Mc.Adam	Color 7 Mc.Donnell	Color 8 Smith	Color 9 Wheaton	Adherence 1 Aupperle	Adherence 2 Buck	Adherence 3 Cooper	Adherence 4 Fleming	Adherence 5 Gibboney	Adherence 6 Mc.Adam	Adherence 7 Mc.Donnell	Adherence 8 Smith	Adherence 9 Wheaton
S	4	C	VC			C	M	C	VC	C	L	L			L	L	L	L	M	L	L			L	L	T	L	T
	5	C	VC			C	M	C	VC	C	L	L			L	L	L	L	M	L	L			L	L	T	L	T
	6	C	VC			C	M	C	VC	C	L	L			L	L	L	L	M	L	L			L	L	T	L	T
	7	C	VC			C	M	C	VC	C	L	L			L	L	L	L	M	L	L			L	L	T	L	T
	8	C	VC			C	M	C	VC	C	L	L			L	L	L	L	M	L	L			L	L	T	L	T
	9	C	VC			C	M	C	VC	C	L	L			L	L	L	L	M	L	L			L	L	T	L	T
	10	C	VC			C	M	C	VC	C	L	L			L	L	L	L	M	L	L			L	L	T	L	T
	11	C	VC			C	M	C	VC	C	L	L			L	L	L	L	M	L	L			L	L	T	L	T
	12	C	VC			C	M	C	VC	C	L	L			L	L	L	L	M	L	L			L	L	T	L	T
	13	C	VC			C	M	C	VC	C	L	L			L	L	L	L	M	L	L			L	L	T	L	T
	14	C	VC			C	M	C	VC	C	L	L			L	L	L	L	M	L	L			L	L	T	L	T
T	4	S	S			M	M	M	C	M	M	D			D	M	D	M	D	T	T			T	T	T	L	T
	5	S	S			M	M	M	C	M	M	D			D	M	D	M	D	T	T			T	T	T	L	T
	6	S	S			M	M	M	C	M	M	D			D	M	D	M	D	T	T			T	T	T	L	T
	7	S	S			M	M	M	C	M	M	D			D	M	D	M	D	T	T			T	T	T	L	T
	8	S	S			M	M	M	C	M	M	D			D	M	D	M	D	T	T			T	T	T	L	T
	9	S	S			M	M	M	C	M	M	D			D	M	D	M	D	T	T			T	T	T	L	T
	10	S	S			M	M	M	C	M	M	D			D	M	D	M	D	T	T			T	T	T	L	T
	11	S	S			M	M	M	C	M	M	D			D	M	D	M	D	T	T			T	T	T	L	T
	12	S	S			M	M	M	C	M	M	D			D	M	D	M	D	T	T			T	T	T	L	T
	13	S	S			M	M	M	C	M	M	D			D	M	D	M	D	T	T			T	T	T	L	T
	14	S	S			M	M	M	C	M	M	D			D	M	D	M	D	T	T			T	T	T	L	T
U	4	M	M			M	M	M	C	C	M	M			M	M	D	M	M	T	T			T	T	T	L	T
	5	M	M			M	M	M	C	C	M	M			M	M	D	M	M	T	T			T	T	T	L	T
	6	M	M			M	M	M	C	C	M	M			M	M	D	M	M	T	T			T	T	T	L	T
	7	M	M			M	M	M	C	C	M	M			M	M	D	M	M	T	T			T	T	T	L	T
	8	M	M			M	M	M	C	C	M	M			M	M	D	M	M	T	T			T	T	T	L	T
	9	M	M			M	M	M	C	C	M	M			M	M	D	M	M	T	T			T	T	T	L	T
	10	M	M			M	M	M	C	C	M	M			M	M	D	M	M	T	T			T	T	T	L	T
	11	M	M			M	M	M	C	C	M	M			M	M	D	M	M	T	T			T	T	T	L	T
	12	M	M			M	M	M	C	C	M	M			M	M	D	M	M	T	T			T	T	T	L	T
	13	M	M			M	M	M	C	C	M	M			M	M	D	M	M	T	T			T	T	T	L	T
	14	M	M			M	M	M	C	C	M	M			M	M	D	M	M	T	T			T	T	T	L	T
V	4	C	M			M	M	M	VC	C	M	M			M	M	D	L	M	T	T			T	T	T	L	T
	5	C	M			M	M	M	VC	C	M	M			M	M	D	L	M	T	T			T	T	T	L	T
	6	C	M			M	M	M	VC	C	M	M			M	M	D	L	M	T	T			T	T	T	L	T
	7	C	M			M	M	M	VC	C	M	M			M	M	D	L	M	T	T			T	T	T	L	T
	8	C	M			M	M	M	VC	C	M	M			M	M	D	L	M	T	T			T	T	T	L	T
	9	C	M			M	M	M	VC	C	M	M			M	M	D	L	M	T	T			T	T	T	L	T
	10	C	M			M	M	M	VC	C	M	M			M	M	D	L	M	T	T			T	T	T	L	T
	11	C	M			M	M	M	VC	C	M	M			M	M	D	L	M	T	T			T	T	T	L	T
	12	C	M			M	M	M	VC	C	M	M			M	M	D	L	M	T	T			T	T	T	L	T
	13	C	M			M	M	M	VC	C	M	M			M	M	D	L	M	T	T			T	T	T	L	T
	14	C	M			M	M	M	VC	C	M	M			M	M	D	L	M	T	T			T	T	T	L	T
Y*	1	C	C			C	M	C	VC	C	M	L			L	M	L	L	M	L	L			L	T	L	L	T
	2	C	C			C	M	C	VC	C	M	L			L	M	L	L	M	L	L			L	T	L	L	T
	3	C	C			C	M	C	VC	C	M	L			L	M	L	L	M	L	L			L	T	L	L	T

* Exposed 8-1-1

ROW No. 10

Designation Mark	Designation Sheet No.	Texture 1 Aupperle	Texture 2 Buck	Texture 3 Cooper	Texture 4 Fleming	Texture 5 Gibboney	Texture 6 Mc.Adam	Texture 7 Mc.Donnell	Texture 8 Smith	Texture 9 Wheaton	Color 1 Aupperle	Color 2 Buck	Color 3 Cooper	Color 4 Fleming	Color 5 Gibboney	Color 6 Mc.Adam	Color 7 Mc.Donnell	Color 8 Smith	Color 9 Wheaton	Adherence 1 Aupperle	Adherence 2 Buck	Adherence 3 Cooper	Adherence 4 Fleming	Adherence 5 Gibboney	Adherence 6 Mc.Adam	Adherence 7 Mc.Donnell	Adherence 8 Smith	Adherence 9 Wheaton
X	4	C	C			C	M	C	C	C	L	L			L	L	L	L	L	L	L			L	L	L	L	T
	5	C	C			C	M	C	C	C	L	L			L	L	L	L	L	L	L			L	L	L	L	T
	6	C	C			C	M	C	C	C	L	L			L	L	L	L	L	L	L			L	L	L	L	T
	7	C	C			C	M	C	C	C	L	L			L	L	L	L	L	L	L			L	L	L	L	T
	8	C	C			C	M	C	C	C	L	L			L	L	L	L	L	L	L			L	L	L	L	T
	9	C	C			C	M	C	C	C	L	L			L	L	L	L	L	L	L			L	L	L	L	T
	10	C	C			C	M	C	C	C	L	L			L	L	L	L	L	L	L			L	L	L	L	T
	11	C	C			C	M	C	C	C	L	L			L	L	L	L	L	L	L			L	L	L	L	T
	12	C	C			C	M	C	C	C	L	L			L	L	L	L	L	L	L			L	L	L	L	T
	13	C	C			C	M	C	C	C	L	L			L	L	L	L	L	L	L			L	L	L	L	T
	14	C	C			C	M	C	C	C	L	L			L	L	L	L	L	L	L			L	L	L	L	T
O	4	C	VC			C	M	C	C	VC	M	L			M	M	M	M	M	L	L			L	T	L	L	T
	5	C	VC			C	M	C	C	VC	M	L			M	M	M	M	M	L	L			L	T	L	L	T
	6	C	VC			C	M	C	C	VC	M	L			M	M	M	M	M	L	L			L	T	L	L	T
	7	C	VC			C	M	C	C	VC	M	L			M	M	M	M	M	L	L			L	T	L	L	T
	8	C	VC			C	M	C	C	VC	M	L			M	M	M	M	M	L	L			L	T	L	L	T
	9	C	VC			C	M	C	C	VC	M	L			M	M	M	M	M	L	L			L	T	L	L	T
	10	C	VC			C	M	C	C	VC	M	L			M	M	M	M	M	L	L			L	T	L	L	T
	11	C	VC			C	M	C	C	VC	M	L			M	M	M	M	M	L	L			L	T	L	L	T
	12	C	VC			C	M	C	C	VC	M	L			M	M	M	M	M	L	L			L	T	L	L	T
Z	101	S	S			S	M	M	M	S	D	M			M	M	D	M	D	T	T			T	T	T	L	T
	102	S	S			S	M	M	M	S	D	M			M	M	D	M	D	T	T			T	T	T	L	T
	103	S	S			S	M	M	M	S	D	M			M	M	D	M	D	T	T			T	T	T	L	T
	202	S	S			M	M	S	M	M	D	M			M	M	D	M	D	T	T			T	T	T	L	T
	204	S	S			M	M	S	M	M	D	M			M	M	D	M	D	T	T			T	T	T	L	T
	206	S	S			M	M	M	M	M	D	M			M	M	D	M	D	T	T			T	T	T	L	T
	301	S	VS			S	M	S	M	M	D	D			M	M	D	M	D	T	T			T	T	T	L	T
	303	S	VS			S	M	S	M	M	D	D			M	M	D	M	D	T	T			T	T	T	L	T
	305	S	VS			S	M	S	M	M	D	D			M	M	D	M	D	T	T			T	T	T	L	T
	417	C	C			C	M	M	C	C	M	L			L	L	M	L	L	L	L			L	L	T	L	T
	418	C	C			C	M	M	C	C	M	L			L	L	M	L	L	L	L			L	L	T	L	T
	419	C	C			C	M	M	C	C	M	L			L	L	M	L	L	L	L			L	L	T	L	T
	501	S	S			S	M	S	M	M	D	D			M	M	D	M	M	T	T			T	T	T	L	T
	503	S	S			S	M	S	M	M	D	D			M	M	D	M	M	T	T			T	T	T	L	T
	504	S	S			S	M	S	M	M	D	D			M	M	D	M	M	T	T			T	T	T	L	T
	602	S	S			S	M	S	M	M	D	D			M	M	D	M	M	T	T			T	T	T	L	T
	603	S	S			S	M	S	M	M	D	D			M	M	D	M	M	T	T			T	T	T	L	T
	604	S	S			S	M	S	M	M	D	D			M	M	D	M	M	T	T			T	T	T	L	T
	702	S	S			S	M	S	M	M	D	D			M	M	D	M	M	T	T			T	T	T	L	T
	706	S	S			S	M	S	M	M	D	D			M	M	D	M	M	T	T			T	T	T	L	T
	707	S	S			S	M	S	M	M	D	D			M	M	D	M	M	T	T			T	T	T	L	T
OOC*	36	C	C			C	M	C	C	C	M	L			L	L	L	L	L	T	L			L	L	L	L	T
YY†	1	C	VC			C	M	VC	C	C	L	L			L	L	L	L	L	L	L			L	L	L	L	T
	2	C	VC			C	M	VC	C	C	L	L			L	L	L	L	L	L	L			L	L	L	L	T
	3	C	VC			C	M	VC	C	C	L	L			L	L	L	L	L	L	L			L	L	L	L	T

* Exposed 11-28-16.

† Exposed 8-1-17.

James B. Gibboney.
Chairman Inspection Committee

Date of Inspection May 10, 1920.

ROW No. 1

DESIGNATION		CONDITION OF RUST Texture									Color									Adherence								
Mark	Sheet No.	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc.Adam 6	Mc.Donnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc.Adam 6	Mc.Donnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc.Adam 6	Mc.Donnell 7	Smith 8	Wheaton 9
AA	11	VC	VC		C	VC	C	C	C	C	L	L		L	L	D	L	M	M	L	L		L	L	L	L	L	T
	12	VC	VC		C	VC	C	C	C	C	L	L		L	L	D	L	M	M	L	L		L	L	L	L	L	T
	13	VC	VC		C	VC	C	C	C	C	L	L		L	L	D	L	M	M	L	L		L	L	L	L	L	T
BB	4	S	S		M	C	M	S	M	M	M	D		D	M	D	D	D	D	T	T		T	T	T	T	T	T
	5	S	S		M	C	M	S	M	M	M	D		D	M	D	D	D	D	T	T		T	T	T	T	T	T
	6	S	S		M	C	M	S	M	M	M	D		D	M	D	D	D	D	T	T		T	T	T	T	T	T
CC	2	M	M		M	C	S	M	M	M	M	L		L	M	M	L	M	M	T	T		T	T	T	T	T	T
	9	M	M		M	C	S	M	M	M	M	L		L	M	M	L	M	M	T	T		T	T	T	T	T	T
	10	M	M		M	C	S	M	M	M	M	L		L	M	M	L	M	M	T	T		T	T	T	T	T	T
DD	18	M	C		M	M	S	M	S	M	M	M		L	M	M	L	M	M	T	TL		T	T	T	T	T	T
	19	M	C		M	M	S	M	S	M	M	M		L	M	M	L	M	M	T	TL		T	T	T	T	T	T
	20	M	C		M	M	S	M	S	M	M	M		L	M	M	L	M	M	T	TL		T	T	T	T	T	T
EE*	7	S	M		M	M	S	M	VS	M	M	D		D	M	D	D	D	M	T	T		T	T	T	T	T	T
	8	S	M		M	M	S	M	VS	M	M	D		D	M	D	M	D	M	T	T		T	T	T	T	T	T
	9	S	M		M	M	S	M	VS	M	M	D		D	M	D	M	D	M	T	T		T	T	T	T	T	T
HH	10	S	S		M	M	S	S	S	M	M	D		D	D	D	M	D	D	T	T		T	T	T	T	T	T
	11	S	S		M	M	S	S	S	M	M	D		D	D	D	M	D	D	T	T		T	T	T	T	T	T
	12	S	S		M	M	S	S	S	M	M	D		D	D	D	M	D	D	T	T		T	T	T	T	T	T
II	10	S	VS		M	S	VS	VS	S	S	M	D		D	M	D	D	D	D	T	T		T	T	T	T	T	T
	11	S	VS		M	S	VS	VS	S	S	M	D		D	M	D	D	D	D	T	T		T	T	T	T	T	T
	12	S	VS		M	S	VS	VS	S	S	M	D		D	M	D	D	D	D	T	T		T	T	T	T	T	T
KK	4	S	VS		M	M	S	VS	S	M	M	D		D	M	D	D	D	D	T	T		T	T	T	T	T	T
	5	S	VS		M	M	S	VS	S	M	M	D		D	M	D	D	D	D	T	T		T	T	T	T	T	T
	18	S	VS		M	M	S	VS	S	M	M	D		D	M	D	D	D	D	T	T		T	T	T	T	T	T
MM*	15	S	M		M	M	M	M	M	M	M	D		D	M	M	D	M	D	T	TL		T	T	L	T	T	T
	16	S	M		M	M	M	M	M	M	M	D		D	M	M	D	M	D	T	TL		T	T	L	T	T	T
	17	S	M		M	M	M	M	M	M	M	D		D	M	M	D	M	D	T	TL		T	T	L	T	T	T
SS	15	S	C		M	C	M	M	C	C	M	L		L	L	L	L	L	M	T	TL		L	T	L	L	T	T
	16	S	C		M	C	M	M	C	C	M	L		L	L	L	L	L	M	T	TL		L	T	L	L	T	T
	17	S	C		M	C	M	M	C	C	M	L		L	L	L	L	L	M	T	TL		L	T	L	L	T	T
TT	15	S	VS		M	S	S	S	S	M	M	D		D	M	D	D	M	D	T	T		T	T	T	T	T	T
	16	S	VS		M	S	S	S	S	M	M	D		D	M	D	D	M	D	T	T		T	T	T	T	T	T
	17	S	VS		M	S	S	S	S	M	M	D		D	M	D	D	M	D	T	T		T	T	T	T	T	T
UU	15	S	S		M	M	M	S	M	M	M	D		M	M	M	M	M	D	T	T		T	T	L	T	T	T
	16	S	S		M	M	M	S	M	M	M	D		M	M	M	M	M	D	T	T		T	T	L	T	T	T
	17	S	S		M	M	M	S	M	M	M	D		M	M	M	M	M	D	T	T		T	T	L	T	T	T
VV	20	S	S		M	S	M	S	S	M	M	D		M	M	M	L	M	D	T	T		T	T	L	T	T	T
	21	S	S		M	S	M	S	S	M	M	D		M	M	M	L	M	D	T	T		T	T	L	T	T	T
	22	S	S		M	S	M	S	S	M	M	D		M	M	M	L	M	D	T	T		T	T	L	T	T	T
XX	15	S	C		M	M	C	C	M	C	M	L		M	M	L	L	M	D	T	L		T	T	L	T	T	T
	16	S	C		M	M	C	C	M	C	M	L		M	M	L	L	M	D	T	L		T	T	L	T	T	T
	17	S	C		M	M	C	C	M	C	M	L		M	M	L	L	M	D	T	L		T	T	L	T	T	T
OO	13	S	C		M	C	C	M	M	M	M	M		D	M	D	M	M	D	T	TL		L	T	L	L	T	T
	14	S	C		M	C	C	M	M	M	M	M		D	M	D	M	M	D	T	TL		L	T	L	L	T	T
	15	S	C		M	C	C	M	M	M	M	M		D	M	D	M	M	D	T	TL		L	T	L	L	T	T
CCC	13	S	M		M	M	M	M	M	M	M	M		D	D	M	L	M	D	T	T		T	T	T	T	T	T
	14	S	M		M	M	M	M	M	M	M	M		D	D	M	L	M	D	T	T		T	T	T	T	T	T
	15	S	M		M	M	M	M	M	M	M	M		D	D	M	L	M	D	T	T		T	T	T	T	T	T

* Open Annealed.

ROW No. 2

DESIGNATION		CONDITION OF RUST Texture									Color									Adherence								
Mark	Sheet No.	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc.Adam 6	Mc.Donnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc.Adam 6	Mc.Donnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc.Adam 6	Mc.Donnell 7	Smith 8	Wheaton 9
A	16	-	VC		C	C	C	C	C	C	-	M		L	M	M	L	M	D	-	L		L	L	L	L	L	T
	17	-	VC		C	C	C	C	C	C	-	M		L	M	M	L	M	D	-	L		L	L	L	L	L	T
	18	-	VC		C	C	C	C	C	C	-	M		L	M	M	L	M	D	-	L		L	L	L	L	L	T
B	9	M	M		M	M	M	M	M	M	M	D		D	M	D	D	M	M	T	TL		T	T	L	T	L	T
	10	M	M		M	M	M	M	M	M	M	D		D	M	D	D	M	M	T	TL		T	T	L	T	L	T
	11	M	M		M	M	M	M	M	M	M	D		D	M	D	D	M	M	T	TL		T	T	L	T	L	T
C	6	M	M		M	M	C	M	M	C	M	M		M	M	M	M	M	M	T	TL		T	T	L	T	T	T
	7	M	M		M	M	C	M	M	C	M	M		M	M	M	M	M	M	T	TL		T	T	L	T	T	T
	8	M	M		M	M	C	M	M	C	M	M		M	M	M	M	M	M	T	TL		T	T	L	T	T	T
D	16	M	C		C	C	M	M	C	VC	M	L		L	L	L	L	L	D	T	L		L	T	L	T	L	T
	19	M	C		C	C	M	M	C	VC	M	L		L	L	L	L	L	D	T	L		L	T	L	T	L	T
	22	M	C		C	C	M	M	C	VC	M	L		L	L	L	L	L	D	T	L		L	T	L	T	L	T
E	13	S	M		M	M	M	M	M	M	D	D		M	M	D	D	M	D	T	L		T	T	T	T	L	T
	14	S	M		M	M	M	M	M	M	D	D		M	M	D	D	M	D	T	L		T	T	T	T	L	T
	15	S	M		M	M	M	M	M	M	D	D		M	M	D	D	M	D	T	L		T	T	T	T	L	T
H	19	S	S		S	S	M	S	M	M	D	D		D	M	D	D	M	D	T	T		T	T	L	T	T	T
	20	S	S		S	S	M	S	M	M	D	D		D	M	D	D	M	D	T	T		T	T	L	T	T	T
	22	S	S		S	S	M	S	M	M	D	D		D	M	D	D	M	D	T	T		T	T	L	T	T	T
I	19	S	VS		S	S	S	VS	M	S	D	D		D	M	D	D	M	D	T	T		T	T	T	T	T	T
	20	S	VS		S	S	S	VS	M	S	D	D		D	M	D	D	M	D	T	T		T	T	T	T	T	T
	21	S	VS		S	S	S	VS	M	S	D	D		D	M	D	D	M	D	T	T		T	T	T	T	T	T
K	17	S	VS		S	S	S	VS	S	S	D	D		D	M	D	D	M	D	T	T		T	T	T	T	T	T
	18	S	VS		S	S	S	VS	S	S	D	D		D	M	D	D	M	D	T	T		T	T	T	T	T	T
	19	S	VS		S	S	S	VS	S	S	D	D		D	M	D	D	M	D	T	T		T	T	T	T	T	T
M	15	S	M		M	M	-	S	M	S	D	M		D	M	-	M	M	D	T	TL		T	T	-	T	T	T
	16	S	M		M	M	-	S	M	S	D	M		D	M	-	D	M	D	T	TL		T	T	-	T	T	T
	17	S	M		M	M	-	S	M	S	D	M		D	M	-	M	M	D	T	TL		T	T	-	T	T	T
S	15	C	VC		C	C	VC	C	C	C	L	L		L	L	L	L	L	M	T	L		L	T	L	L	L	T
	16	C	VC		C	C	VC	C	C	C	L	L		L	L	L	L	L	M	T	L		L	T	L	L	L	T
	17	C	VC		C	C	VC	C	C	C	L	L		L	L	L	L	L	M	T	L		L	T	L	L	L	T
T	15	S	S		S	M	C	M	M	M	D	D		D	M	M	D	M	D	T	T		T	T	L	T	T	T
	16	S	S		S	M	C	M	M	M	D	D		D	M	M	D	M	D	T	T		T	T	L	T	T	T
	17	S	S		S	M	C	M	M	M	D	D		D	M	M	D	M	D	T	T		T	T	L	T	T	T
U	15	M	M		M	S	C	M	M	C	M	D		M	M	L	D	M	D	T	T		T	T	L	T	T	T
	16	M	M		M	S	C	M	M	C	M	D		M	M	L	D	M	D	T	T		T	T	L	T	T	T
	17	M	M		M	S	C	M	M	C	M	D		M	M	L	D	M	D	T	T		T	T	L	T	T	T
V	15	S	M		M	M	C	M	M	M	M	D		M	M	L	D	M	D	T	T		T	T	L	T	T	T
	16	S	M		M	M	C	M	M	M	M	D		M	M	L	D	M	D	T	T		T	T	L	T	T	T
	17	S	M		M	M	C	M	M	M	M	D		M	M	L	D	M	D	T	T		T	T	L	T	T	T
X	15	C	C		C	C	C	C	C	C	L	L		L	M	L	M	L	M	T	L		L	T	L	L	L	T
	16	C	C		C	C	C	C	C	C	L	L		L	M	L	M	L	M	T	L		L	T	L	L	L	T
	17	C	C		C	C	C	C	C	C	L	L		L	M	L	M	L	M	T	L		L	T	L	L	L	T
O	13	-	VC		VC	VC	VC	C	VC	VC	-	L		L	D	L	M	L	M	-	L		L	L	L	L	L	T
	14	-	VC		VC	VC	VC	C	VC	VC	-	L		L	D	L	M	L	M	-	L		L	L	L	L	L	T
	15	-	VC		VC	VC	VC	C	VC	VC	-	L		L	D	L	M	L	M	-	L		L	L	L	L	L	T
Z	1	C	C		VC	C	C	C	C	C	L	L		L	M	L	M	L	M	T	L		L	L	L	L	L	T
	3	C	C		VC	C	C	C	C	C	L	L		L	M	L	M	L	M	T	L		L	L	L	L	L	T
	104	S	S		S	VS	S	S	S	S	D	D		D	D	D	D	D	D	T	T		T	T	T	T	T	T

ROW No. 3

DESIGNATION		CONDITION OF RUST Texture									Color									Adherence								
Mark	Sheet No.	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc.Adam 6	Mc.Donnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc.Adam 6	Mc.Donnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc.Adam 6	Mc.Donnell 7	Smith 8	Wheaton 9
AA	14	VC	VC		VC	VC	VC	C	C	VC	L	M		L	L	L	L	L	M	L	L		L	L	L	L	L	L
	15	VC	VC		VC	VC	VC	C	C	VC	L	M		L	L	L	L	L	M	L	L		L	L	L	L	L	L
	16	VC	VC		VC	VC	VC	C	C	VC	L	M		L	L	L	L	L	M	L	L		L	L	L	L	L	L
	17	VC	VC		VC	VC	VC	C	C	VC	L	M		L	L	L	L	L	M	L	L		L	L	L	L	L	L
	18	VC	VC		VC	VC	VC	C	C	VC	L	M		L	L	L	L	L	M	L	L		L	L	L	L	L	L
	19	VC	VC		VC	VC	VC	C	C	VC	L	M		L	L	L	L	L	M	L	L		L	L	L	L	L	L
	20	VC	VC		VC	VC	VC	C	C	VC	L	M		L	L	L	L	L	M	L	L		L	L	L	L	L	L
AA†	42	VC	VC		VC	C	VC	C	C	VC	L	M		L	M	L	L	L	M	L	L		L	T	L	L	L	L
	43	VC	VC		VC	C	VC	C	C	VC	L	M		L	M	L	L	L	M	L	L		L	T	L	L	L	L
	44	VC	VC		VC	C	VC	C	C	VC	L	M		L	M	L	L	L	M	L	L		L	T	L	L	L	L
	45	VC	VC		VC	C	VC	C	C	VC	L	M		L	M	L	L	L	M	L	L		L	T	L	L	L	L
	46	VC	VC		VC	C	VC	C	C	VC	L	M		L	M	L	L	L	M	L	L		L	T	L	L	L	L
	47	VC	VC		VC	C	VC	C	C	VC	L	M		L	M	L	L	L	M	L	L		L	T	L	L	L	L
	48	VC	VC		VC	C	VC	C	C	VC	L	M		L	M	L	L	L	M	L	L		L	T	L	L	L	L
	49	VC	VC		VC	C	VC	C	C	VC	L	M		L	M	L	L	L	M	L	L		L	T	L	L	L	L
BB	7	S	S		M	M	M	M	S	M	M	D		D	M	D	D	M	D	T	T		T	T	L	T	T	T
	15	S	S		M	M	M	M	S	M	M	D		D	M	D	D	M	D	T	T		T	T	L	T	T	T
	16	S	S		M	M	M	M	S	M	M	D		D	M	D	D	M	D	T	T		T	T	L	T	T	T
	17	S	S		M	M	M	M	S	M	M	D		D	M	D	D	M	D	T	T		T	T	L	T	T	T
	18	S	S		M	M	M	M	S	M	M	D		D	M	D	D	M	D	T	T		T	T	L	T	T	T
	19	S	S		M	M	M	M	S	M	M	D		D	M	D	D	M	D	T	T		T	T	L	T	T	T
BB*	29	S	S		M	S	M	M	S	S	M	D		D	M	D	D	M	D	T	T		T	T	L	T	T	T
	30	S	S		M	S	M	M	S	S	M	D		D	M	D	D	M	D	T	T		T	T	L	T	T	T
	31	S	S		M	S	M	M	S	S	M	D		D	M	D	D	M	D	T	T		T	T	L	T	T	T
	32	S	S		M	S	M	M	S	S	M	D		D	M	D	D	M	D	T	T		T	T	L	T	T	T
	46	S	S		M	S	M	M	S	S	M	D		D	M	D	D	M	D	T	T		T	T	L	T	T	T
	47	S	S		M	S	M	M	S	S	M	D		D	M	D	D	M	D	T	T		T	T	L	T	T	T
	48	S	S		M	S	M	M	S	S	M	D		D	M	D	D	M	D	T	T		T	T	L	T	T	T
	49	S	S		M	S	M	M	S	S	M	D		D	M	D	D	M	D	T	T		T	T	L	T	T	T
CC	11	C	M		C	C	C	M	M	C	M	L		L	L	L	L	L	C	L	TL		L	T	L	T	T	T
	12	C	M		C	C	C	M	M	C	M	L		L	L	L	L	L	C	L	TL		L	T	L	T	T	T
	13	C	M		C	C	C	M	M	C	M	L		L	L	L	L	L	C	L	TL		L	T	L	T	T	T
	14	C	M		C	C	C	M	M	C	M	L		L	L	L	L	L	C	L	TL		L	T	L	T	T	T
CC*	26	C	M		C	M	C	M	M	M	M	L		L	M	L	L	L	M	L	TL		L	T	L	T	L	T
	27	C	M		C	M	C	M	M	M	M	L		L	M	L	L	L	M	L	TL		L	T	L	T	L	T
	28	C	M		C	M	C	M	M	M	M	L		L	M	L	L	L	M	L	TL		L	T	L	T	L	T
	29	C	M		C	M	C	M	M	M	M	L		L	M	L	L	L	M	L	TL		L	T	L	T	L	T
	30	C	M		C	M	C	M	M	M	M	L		L	M	L	L	L	M	L	TL		L	T	L	T	L	T
DD	5	M	C		C	C	C	M	C	C	M	L		L	M	L	L	L	M	T	L		L	T	L	T	L	T
	6	M	C		C	C	C	M	C	C	M	L		L	M	L	L	L	M	T	L		L	T	L	T	L	T
	7	M	C		C	C	C	M	C	C	M	L		L	M	L	L	L	M	T	L		L	T	L	T	L	T
	21	M	C		C	C	C	M	M	C	M	L		L	M	L	L	L	M	T	L		L	T	L	T	T	T
	22	M	C		C	C	C	M	M	C	M	L		L	M	L	L	L	M	T	L		L	T	L	T	T	T
	23	M	C		C	C	C	M	M	C	M	L		L	M	L	L	L	M	T	L		L	T	L	T	T	T
	24	M	C		C	C	C	M	M	C	M	L		L	M	L	L	L	M	T	L		L	T	L	T	T	T
YY†	6	M	VC		C	C	C	C	M	C	M	L		L	M	L	L	L	M	T	L		L	T	L	L	T	
	4	M	VC		C	C	C	C	M	C	M	L		L	M	L	L	L	M	T	L		L	T	L	L	T	
	3	M	VC		C	C	C	C	M	C	M	L		L	M	L	L	L	M	T	L		L	T	L	L	T	
Y†	1	M	VC		C	M	C	C	M	M	M	L		M	M	L	L	L	M	T	L		L	T	L	L	L	

* Sand Blasted.

† Exposed 6-13-17.

— INSPECTION COMMITTEE —

J. H. Gibboney, Chairman – Norfolk & Western Ry. Co.
J. A. Aupperle — American Rolling Mill Co.
D. M. Buck — American Steel & Tin Plate Co.
W. A. Cooper — Alan Wood Iron & Steel Co.
W. R. Fleming — The Andrews Steel Co.
D. J. Mc.Adam Jr. — U. S. Navy, Bureau Steam Engineering.
M. E. Mc.Donnell — Pennsylvania Railroad Co.
H. E. Smith — New York Central Railroad Co.
F. B. Wheaton — U. S. Army, Quartermaster's Corps.

CONDITION OF RUST.

Texture	Color	Adherence
VS—Very Smooth	L—Light	T—Tight
S—Smooth	M—Medium	L—Loose
M—Medium	D—Dark	
C—Coarse		
VC—Very Coarse		

— J. A. AUPPERLE —

NOTES:
A – 16, 17, 18 – Failure.
O – 13, 14, 15 – "
OO – 18, 19, 20, 21, 22 – Scabby.
U – 25, 26 – Rifle Hole.
O – 16 – Failure.
O – 17 – Bent at Top.
O – 19, 21, 23, 24 – Failure.
O – 20 – Bent at Top.
Z – 421 – Failure.

— D. M. BUCK —

A – 16, 17, 18 – Failures
O – 13, 14, 15 – "
O – 16, 19, 21, 23, 24 – "
Z – 421 – Failure.

TABLE III.—RESULTS OF INSPECTION OF CORROSION TEST SHEETS, AT FORT SHERIDAN, ILL., MAY 10, 1920.

AMERICAN SOCIETY FOR TESTING MATERIALS

COMMITTEE A-5 ON CORROSION OF IRON AND STEEL
TESTS OF UNCOATED SHEETS
FORT SHERIDAN, ILL.
EXPOSED APRIL 9, 1917

Date of Inspection *May 10, 1920.*

Weather *Clear*

No. 3

Mark	Sheet No.	Texture									Color									Adherence								
		Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc.Adam 6	Mc.Donnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc.Adam 6	Mc.Donnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc.Adam 6	Mc.Donnell 7	Smith 8	Wheaton 9
	14	VC	VC		VC	VC	VC	C	C	VC	L	M		L	L	L	L	L	M	L	L		L	L	L	L	L	L
	15	VC	VC		VC	VC	VC	C	C	VC	L	M		L	L	L	L	L	M	L	L		L	L	L	L	L	L
	16	VC	VC		VC	VC	VC	C	C	VC	L	M		L	L	L	L	L	M	L	L		L	L	L	L	L	L
	17	VC	VC		VC	VC	VC	C	C	VC	L	M		L	L	L	L	L	M	L	L		L	L	L	L	L	L
	18	VC	VC		VC	VC	VC	C	C	VC	L	M		L	L	L	L	L	M	L	L		L	L	L	L	L	L
	19	VC	VC		VC	VC	VC	C	C	VC	L	M		L	L	L	L	L	M	L	L		L	L	L	L	L	L
	20	VC	VC		VC	VC	VC	C	C	VC	L	M		L	L	L	L	L	M	L	L		L	L	L	L	L	L
	42	VC	VC		VC	C	VC	C	C	VC	L	M		L	M	L	L	L	M	L	L		L	T	L	L	L	L
	43	VC	VC		VC	C	VC	C	C	VC	L	M		L	M	L	L	L	M	L	L		L	T	L	L	L	L
	44	VC	VC		VC	C	VC	C	C	VC	L	M		L	M	L	L	L	M	L	L		L	T	L	L	L	L
	45	VC	VC		VC	C	VC	C	C	VC	L	M		L	M	L	L	L	M	L	L		L	T	L	L	L	L
	46	VC	VC		VC	C	VC	C	C	VC	L	M		L	M	L	L	L	M	L	L		L	T	L	L	L	L
	47	VC	VC		VC	C	VC	C	C	VC	L	M		L	M	L	L	L	M	L	L		L	T	L	L	L	L
	48	VC	VC		VC	C	VC	C	C	VC	L	M		L	M	L	L	L	M	L	L		L	T	L	L	L	L
	49	VC	VC		VC	C	VC	C	C	VC	L	M		L	M	L	L	L	M	L	L		L	T	L	L	L	L
	7	S	S		M	M	M	M	S	M	M	D		D	M	D	D	M	D	T	T		T	T	L	T	T	T
	15	S	S		M	M	M	M	S	M	M	D		D	M	D	D	M	D	T	T		T	T	L	T	T	T
	16	S	S		M	M	M	M	S	M	M	D		D	M	D	D	M	D	T	T		T	T	L	T	T	T
	17	S	S		M	M	M	M	S	M	M	D		D	M	D	D	M	D	T	T		T	T	L	T	T	T
	18	S	S		M	M	M	M	S	M	M	D		D	M	D	D	M	D	T	T		T	T	L	T	T	T
	19	S	S		M	M	M	M	S	M	M	D		D	M	D	D	M	D	T	T		T	T	L	T	T	T
	29	S	S		M	S	M	M	S	S	M	D		D	M	D	D	M	D	T	T		T	T	L	T	T	T
	30	S	S		M	S	M	M	S	S	M	D		D	M	D	D	M	D	T	T		T	T	L	T	T	T
	31	S	S		M	S	M	M	S	S	M	D		D	M	D	D	M	D	T	T		T	T	L	T	T	T
	32	S	S		M	S	M	M	S	S	M	D		D	M	D	D	M	D	T	T		T	T	L	T	T	T
	46	S	S		M	S	M	M	S	S	M	D		D	M	D	D	M	D	T	T		T	T	L	T	T	T
	47	S	S		M	S	M	M	S	S	M	D		D	M	D	D	M	D	T	T		T	T	L	T	T	T
	48	S	S		M	S	M	M	S	S	M	D		D	M	D	D	M	D	T	T		T	T	L	T	T	T
	49	S	S		M	S	M	M	S	S	M	D		D	M	D	D	M	D	T	T		T	T	L	T	T	T
	11	C	M		C	C	C	M	M	C	M	L		L	L	L	L	L	C	L	TL		L	T	L	T	T	T
	12	C	M		C	C	C	M	M	C	M	L		L	L	L	L	L	C	L	TL		L	T	L	T	T	T
	13	C	M		C	C	C	M	M	C	M	L		L	L	L	L	L	C	L	TL		L	T	L	T	T	T
	14	C	M		C	C	C	M	M	C	M	L		L	L	L	L	L	C	L	TL		L	T	L	T	T	T
	26	C	M		C	M	C	M	M	M	M	L		L	M	L	L	L	M	L	TL		L	T	L	T	L	T
	27	C	M		C	M	C	M	M	M	M	L		L	M	L	L	L	M	L	TL		L	T	L	T	L	T
	28	C	M		C	M	C	M	M	M	M	L		L	M	L	L	L	M	L	TL		L	T	L	T	L	T
	29	C	M		C	M	C	M	M	M	M	L		L	M	L	L	L	M	L	TL		L	T	L	T	L	T
	30	C	M		C	M	C	M	M	M	M	L		L	M	L	L	L	M	L	TL		L	T	L	T	L	T
	5	M	C		C	C	C	M	C	C	M	L		L	M	L	L	L	M	T	L		L	T	L	T	L	T
	6	M	C		C	C	C	M	C	C	M	L		L	M	L	L	L	M	T	L		L	T	L	T	L	T
	7	M	C		C	C	C	M	C	C	M	L		L	M	L	L	L	M	T	L		L	T	L	T	L	T
	21	M	C		C	C	C	M	M	C	M	L		L	M	L	L	L	M	T	L		L	T	L	T	T	T
	22	M	C		C	C	C	M	M	C	M	L		L	M	L	L	L	M	T	L		L	T	L	T	T	T
	23	M	C		C	C	C	M	M	C	M	L		L	M	L	L	L	M	T	L		L	T	L	T	T	T
	24	M	C		C	C	C	M	M	C	M	L		L	M	L	L	L	M	T	L		L	T	L	T	T	T
†	6	M	VC		C	C	C	C	M	C	M	L		L	M	L	L	L	M	T	L		L	T	L	L	T	T
	4	M	VC		C	C	C	C	M	C	M	L		L	M	L	L	L	M	T	L		L	T	L	L	T	T
	5	M	VC		C	C	C	C	M	C	M	L		L	M	L	L	L	M	T	L		L	T	L	L	T	T
†	1	M	VC		C	M	C	C	M	M	M	L		M	M	L	L	L	M	T	L		L	T	L	L	L	T

ROW No. 4

Mark	Sheet No.	Texture									Color									Adherence								
		Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc.Adam 6	Mc.Donnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc.Adam 6	Mc.Donnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc.Adam 6	Mc.Donnell 7	Smith 8	Wheaton 9
DD*	39	M	C		C	M	C	M	C	C	M	L		L	M	M	M	M	M	T	L		L	T	L	T	T	T
	40	M	C		C	M	C	M	C	C	M	L		L	M	M	M	M	M	T			L	T	L	T	T	T
	44	M	C		C	M	C	M	C	C	M	L		L	M	M	M	M	M	T			L	T	L	T	T	T
	45	M	C		C	M	C	M	C	C	M	L		L	M	M	M	M	M	T			L	T	L	T	T	T
	46	M	C		C	M	C	M	C	C	M	L		L	M	M	M	M	M	T			L	T	L	T	T	T
	50	M	C		C	M	C	M	C	C	M	L		L	M	M	M	M	M	T			L	T	L	T	T	T
	51	M	C		C	M	C	M	C	C	M	L		L	M	M	M	M	M	T			L	T	L	T	T	T
	52	M	C		C	M	C	M	C	C	M	L		L	M	M	M	M	M	T			L	T	L	T	T	T
	53	M	C		C	M	C	M	C	C	M	L		L	M	M	M	M	M	T			L	T	L	T	T	T
EE†	10	S	M		M	C	C	M	M	M	D	D		D	M	D	D	D	D	T	TL		T	T	L	T	T	T
	11	S	M		M	C	C	M	M	M	D	D		D	M	D	D	D	D	T	TL		T	T	L	T	T	T
	12	S	M		M	C	C	M	M	M	D	D		D	M	D	D	D	D	T	TL		T	T	L	T	T	T
EE*†	25	S	S		M	M	M	M	S	M	D	D		D	M	D	D	D	D	T	TL		T	T	L	T	T	T
	26	S	S		M	M	M	M	S	M	D	D		D	M	D	D	D	D	T	TL		T	T	L	T	T	T
	27	S	S		M	M	M	M	S	M	D	D		D	M	D	D	D	D	T	TL		T	T	L	T	T	T
	28	S	S		M	M	M	M	S	M	D	D		D	M	D	D	D	D	T	TL		T	T	L	T	T	T
	29	S	S		M	M	M	M	S	M	D	D		D	M	D	D	D	D	T	TL		T	T	L	T	T	T
	30	S	S		M	M	M	M	S	M	D	D		D	M	D	D	D	D	T	TL		T	T	L	T	T	T
HH	13	S	S		M	S	M	S	S	M	D	D		D	M	D	D	D	D	T	TL		T	T	L	T	T	T
	14	S	S		M	S	M	S	S	M	D	D		D	M	D	D	D	D	T	TL		T	T	L	T	T	T
	15	S	S		M	S	M	S	S	M	D	D		D	M	D	D	D	D	T	TL		T	T	L	T	T	T
	16	S	S		M	S	M	S	S	M	D	D		D	M	D	D	D	D	T	TL		T	T	L	T	T	T
	17	S	S		M	S	M	S	S	M	D	D		D	M	D	D	D	D	T	TL		T	T	L	T	T	T
	18	S	S		M	S	M	S	S	M	D	D		D	M	D	D	D	D	T	TL		T	T	L	T	T	T
HH*	35	S	S		M	S	M	S	S	M	D	D		D	D	D	D	D	D	T	TL		T	T	L	T	T	T
	36	S	S		M	S	M	S	S	M	D	D		D	D	D	D	D	D	T	TL		T	T	L	T	T	T
	37	S	S		M	S	M	S	S	M	D	D		D	D	D	D	D	D	T	TL		T	T	L	T	T	T
	38	S	S		M	S	M	S	S	M	D	D		D	D	D	D	D	D	T	TL		T	T	L	T	T	T
	39	S	S		M	S	M	S	S	M	D	D		D	D	D	D	D	D	T	TL		T	T	L	T	T	T
	40	S	S		M	S	M	S	S	M	D	D		D	D	D	D	D	D	T	TL		T	T	L	T	T	T
	41	S	S		M	S	M	S	S	M	D	D		D	D	D	D	D	D	T	TL		T	T	L	T	T	T
	42	S	S		M	S	M	S	S	M	D	D		D	D	D	D	D	D	T	TL		T	T	L	T	T	T
II	13	S	VS		M	S	C	VS	S	S	D	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	14	S	VS		M	S	C	VS	S	S	D	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	15	S	VS		M	S	C	VS	S	S	D	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	16	S	VS		M	S	C	VS	S	S	D	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	17	S	VS		M	S	C	VS	S	S	D	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	18	S	VS		M	S	C	VS	S	S	D	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	19	S	VS		M	S	C	VS	S	S	D	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
II#	39	S	VS		M	S	C	VS	S	S	D	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	40	S	VS		M	S	C	VS	S	S	D	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	41	S	VS		M	S	C	VS	S	S	D	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	42	S	VS		M	S	C	VS	S	S	D	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	43	S	VS		M	S	C	VS	S	S	D	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	44	S	VS		M	S	C	VS	S	S	D	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	45	S	VS		M	S	C	VS	S	S	D	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	46	S	VS		M	S	C	VS	S	S	D	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	47	S	VS		M	S	C	VS	S	S	D	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T

ROW No. 5

Mark	Sheet No.	Texture									Color									Adherence								
		Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc.Adam 6	Mc.Donnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc.Adam 6	Mc.Donnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc.Adam 6	Mc.Donnell 7	Smith 8	Wheaton 9
KK	19	S	VS		S	S	M	S	VS	S	D	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	20	S	VS		S	S	M	S	VS	S	D	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	21	S	VS		S	S	M	S	VS	S	D	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	22	S	VS		S	S	M	S	VS	S	D	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	23	S	VS		S	S	M	S	VS	S	D	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	24	S	VS		S	S	M	S	VS	S	D	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	25	S	VS		S	S	M	S	VS	S	D	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	26	S	VS		S	S	M	S	VS	S	D	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
KK*	43	S	VS		S	S	M	S	VS	S	D	D		D	D	D	D	D	D	T	T		T	T	L	T	T	T
	44	S	VS		S	S	M	S	VS	S	D	D		D	D	D	D	D	D	T	T		T	T	L	T	T	T
	45	S	VS		S	S	M	S	VS	S	D	D		D	D	D	D	D	D	T	T		T	T	L	T	T	T
	46	S	VS		S	S	M	S	VS	S	D	D		D	D	D	D	D	D	T	T		T	T	L	T	T	T
	47	S	VS		S	S	M	S	VS	S	D	D		D	U	D	D	D	D	T	T		T	T	L	T	T	T
	48	S	VS		S	S	M	S	VS	S	D	D		D	D	D	D	D	D	T	T		T	T	L	T	T	T
	49	S	VS		S	S	M	S	VS	S	D	D		D	D	D	D	D	D	T	T		T	T	L	T	T	T
	50	S	VS		S	S	M	S	VS	S	D	D		D	D	D	D	D	D	T	T		T	T	L	T	T	T
MM†	18	M	M		M	C	C	M	S	M	D	D		D	L	M	M	D	D	T	TL		T	T	L	T	T	T
	19	M	M		M	C	C	M	S	M	D	D		D	L	M	M	D	D	T	TL		T	T	L	T	T	T
	20	M	M		M	C	C	M	S	M	D	D		D	L	M	M	D	D	T	TL		T	T	L	T	T	T
	21	M	M		M	C	C	M	S	M	D	D		D	L	M	M	D	D	T	TL		T	T	L	T	T	T
	22	M	M		M	C	C	M	S	M	D	D		D	L	M	M	D	D	T	TL		T	T	L	T	T	T
	23	M	M		M	C	C	M	S	M	D	D		D	L	M	M	D	D	T	TL		T	T	L	T	T	T
	24	M	M		M	C	C	M	S	M	D	D		D	L	M	M	D	D	T	TL		T	T	L	T	T	T
	25	M	M		M	C	C	M	S	M	D	D		D	L	M	M	D	D	T	TL		T	T	L	T	T	T
	26	M	M		M	C	C	M	S	M	D	D		D	L	M	M	D	D	T	TL		T	T	L	T	T	T
	27	M	M		M	C	C	M	S	M	D	D		D	L	M	M	D	D	T	TL		T	T	L	T	T	T
	28	M	M		M	C	C	M	S	M	D	D		D	L	M	M	D	D	T	TL		T	T	L	T	T	T
SS	18	M	VC		C	C	VC	M	M	C	L	L		L	L	L	L	L	M	T	L		L	T	L	L	L	T
	19	M	VC		C	C	VC	M	M	C	L	L		L	L	L	L	L	M	T	L		L	T	L	L	L	T
	20	M	VC		C	C	VC	M	M	C	L	L		L	L	L	L	L	M	T	L		L	T	L	L	L	T
	22	M	VC		C	C	VC	M	M	C	L	L		L	L	L	L	L	M	T	L		L	T	L	L	L	T
	23	M	VC		C	C	VC	M	M	C	L	L		L	L	L	L	L	M	T	L		L	T	L	L	L	T
	24	M	VC		C	C	VC	M	M	C	L	L		L	L	L	L	L	M	T	L		L	T	L	L	L	T
	25	M	VC		C	C	VC	M	M	C	L	L		L	L	L	L	L	M	T	L		L	T	L	L	L	T
	26	M	VC		C	C	VC	M	M	C	L	L		L	L	L	L	L	M	T	L		L	T	L	L	L	T
	27	M	VC		C	C	VC	M	M	C	L	L		L	L	L	L	L	M	T	L		L	T	L	L	L	T
TT	18	S	VS		S	M	C	M	S	M	D	D		D	D	M	D	M	D	T	T		T	T	L	T	T	T
	19	S	VS		S	M	C	M	S	M	D	D		D	D	M	D	M	D	T	T		T	T	L	T	T	T
	20	S	VS		S	M	C	M	S	M	D	D		D	D	M	D	M	D	T	T		T	T	L	T	T	T
	21	S	VS		S	M	C	M	S	M	D	D		D	D	M	D	M	D	T	T		T	T	L	T	T	T
	22	S	VS		S	M	C	M	S	M	D	D		D	D	M	D	M	D	T	T		T	T	L	T	T	T
	23	S	VS		S	M	C	M	S	M	D	D		D	D	M	D	M	D	T	T		T	T	L	T	T	T
	24	S	VS		S	M	C	M	S	M	D	D		D	D	M	D	M	D	T	T		T	T	L	T	T	T
	25	S	VS		S	M	C	M	S	M	D	D		D	D	M	D	M	D	T	T		T	T	L	T	T	T
	26	S	VS		S	M	C	M	S	M	D	D		D	D	M	D	M	D	T	T		T	T	L	T	T	T
	27	S	VS		S	M	C	M	S	M	D	D		D	D	M	D	M	D	T	T		T	T	L	T	T	T
	28	S	VS		S	M	C	M	S	M	D	D		D	D	M	D	M	D	T	T		T	T	L	T	T	T
Y‡	6	M	C		M	C	VC	M	M	C	M	M		M	L	L	L	M	M	T	L		L	T	L	L	T	T
	5	M	C		M	C	VC	M	M	C	M	M		M	L	L	L	M	M	T	L		L	T	L	L	T	T

ROW No. 6

Mark	Sheet No.	Texture									Color									Adherence								
		Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc.Adam 6	Mc.Donnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc.Adam 6	Mc.Donnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc.Adam 6	Mc.Donnell 7	Smith 8	Wheaton 9
UU	18	M	S		M	M	M	M	S	M	M	D		D	M	M	M	M	M	T	T		T	T	L	T	T	T
	19	M	S		M	M	M	M	S	M	M	D		D	M	M	M	M	M	T	T		T	T	L	T	T	T
	20	M	S		M	M	M	M	S	M	M	D		D	M	M	M	M	M	T	T		T	T	L	T	T	T
	22	M	S		M	M	M	M	S	M	M	D		D	M	M	M	M	M	T	T		T	T	L	T	T	T
	23	M	S		M	M	M	M	S	M	M	D		D	M	M	M	M	M	T	T		T	T	L	T	T	T
	24	M	S		M	M	M	M	S	M	M	D		D	M	M	M	M	M	T	T		T	T	L	T	T	T
	25	M	S		M	M	M	M	S	M	M	D		D	M	M	M	M	M	T	T		T	T	L	T	T	T
	26	M	S		M	M	M	M	S	M	M	D		D	M	M	M	M	M	T	T		T	T	L	T	T	T
	27	M	S		M	M	M	M	S	M	M	D		D	M	M	M	M	M	T	T		T	T	L	T	T	T
	28	M	S		M	M	M	M	S	M	M	D		D	M	M	M	M	M	T	T		T	T	L	T	T	T
VV	23	M	S		M	M	C	M	M	M	M	D		D	M	M	M	M	M	T	T		T	T	L	T	T	T
	24	M	S		M	M	C	M	M	M	M	D		D	M	M	M	M	M	T	T		T	T	L	T	T	T
	25	M	S		M	M	C	M	M	M	M	D		D	M	M	M	M	M	T	T		T	T	L	T	T	T
	26	M	S		M	M	C	M	M	M	M	D		D	M	M	M	M	M	T	T		T	T	L	T	T	T
	27	M	S		M	M	C	M	M	M	M	D		D	M	M	M	M	M	T	T		T	T	L	T	T	T
	28	M	S		M	M	C	M	M	M	M	D		D	M	M	M	M	M	T	T		T	T	L	T	T	T
	29	M	S		M	M	C	M	M	M	M	D		D	M	M	M	M	M	T	T		T	T	L	T	T	T
	30	M	S		M	M	C	M	M	M	M	D		D	M	M	M	M	M	T	T		T	T	L	T	T	T
	31	M	S		M	M	C	M	M	M	M	D		D	M	M	M	M	M	T	T		T	T	L	T	T	T
	32	M	S		M	M	C	M	M	M	M	D		D	M	M	M	M	M	T	T		T	T	L	T	T	T
	33	M	S		M	M	C	M	M	M	M	D		D	M	M	M	M	M	T	T		T	T	L	T	T	T
	34	M	S		M	M	C	M	M	M	M	D		D	M	M	M	M	M	T	T		T	T	L	T	T	T
	35	M	S		M	M	C	M	M	M	M	D		D	M	M	M	M	M	T	T		T	T	L	T	T	T
	36	M	S		M	M	C	M	M	M	M	D		D	M	M	M	M	M	T	T		T	T	L	T	T	T
	37	M	S		M	M	C	M	M	M	M	D		D	M	M	M	M	M	T	T		T	T	L	T	T	T
	38	M	S		M	M	C	M	M	M	M	D		D	M	M	M	M	M	T	T		T	T	L	T	T	T
XX	18	C	C		M	C	C	C	M	C	M	M		L	M	L	L	M	M	L	L		L	T	L	L	T	T
	19	C	C		M	C	C	C	M	C	M	M		L	M	L	L	M	M	L	L		L	T	L	L	T	T
	20	C	C		M	C	C	C	M	C	M	M		L	M	L	L	M	M	L	L		L	T	L	L	T	T
	21	C	C		M	C	C	C	M	C	M	M		L	M	L	L	M	M	L	L		L	T	L	L	T	T
	22	C	C		M	C	C	C	M	C	M	M		L	M	L	L	M	M	L	L		L	T	L	L	T	T
	23	C	C		M	C	C	C	M	C	M	M		L	M	L	L	M	M	L	L		L	T	L	L	T	T
	24	C	C		M	C	C	C	M	C	M	M		L	M	L	L	M	M	L	L		L	T	L	L	T	T
	25	C	C		M	C	C	C	M	C	M	M		L	M	L	L	M	M	L	L		L	T	L	L	T	T
	26	C	C		M	C	C	C	M	C	M	M		L	M	L	L	M	M	L	L		L	T	L	L	T	T
	27	C	C		M	C	C	C	M	C	M	M		L	M	L	L	M	M	L	L		L	T	L	L	T	T
	28	C	C		M	C	C	C	M	C	M	M		L	M	L	L	M	M	L	L		L	T	L	L	T	T
ZZ	5	VC	C		C	M	M	C	C	C	L	L		L	L	D	L	M	M	L	L		L	T	L	L	L	T
	7	VC	C		C	M	M	C	C	C	L	L		L	L	D	L	M	M	L	L		L	T	L	L	L	T
	308	VS	VS		VS	S	M	S	VS	S	D	D		D	D	D	D	D	D	T	T		T	T	L	T	T	T
	309	VS	VS		VS	S	M	S	VS	S	D	D		D	D	D	D	D	D	T	T		T	T	L	T	T	T
	505	S	VS		M	S	M	M	S	M	D	D		M	M	D	M	D	D	T	T		T	T	L	T	T	T
	506	S	VS		M	S	M	M	S	M	D	D		M	M	D	M	D	D	T	T		T	T	L	T	T	T
	610	VS	VS		VS	VS	M	S	VS	S	D	D		D	D	D	D	D	D	T	T		T	T	L	T	T	T
	611	VS	VS		VS	VS	M	S	VS	S	D	D		D	D	D	D	D	D	T	T		T	T	L	T	T	T

ROW No. 7

Mark	Sheet No.	Texture									Color									Adherence								
		Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc.Adam 6	Mc.Donnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc.Adam 6	Mc.Donnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc.Adam 6	Mc.Donnell 7	Smith 8	Wheaton 9
ZZ	106	M	VS		M	S	C	S	VS	M	D	D		D	D	M	D	D	D	T	T		T	T	L	T	T	T
	205	M	VS		S	S	C	S	VS	M	D	D		D	D	M	D	D	D	T	T		T	T	L	T	T	T
	206	S	VS		S	S	C	S	VS	M	D	D		D	D	M	D	D	D	T	T		T	T	L	T	T	T
	420	S	C		M	C	C	M	S	M	D	M		M	M	M	M	D	D	T	L		T	T	L	T	T	T
	422	S	C		M	C	C	M	S	M	D	M		M	M	M	M	D	D	T	L		T	T	L	T	T	T
	712	VS	VS		S	M	C	S	VS	S	D	D		D	M	M	D	D	D	T	T		T	T	L	T	T	T
	713	VS	VS		S	M	C	S	VS	S	D	D		D	M	M	D	D	D	T	T		T	T	L	T	T	T
OO	16	C	VC		C	M	C	C	M	C	M	M		L	L	L	M	M	D	L	L		L	T	L	L	T	T
	17	C	VC		C	M	C	C	M	C	M	M		L	L	L	M	M	D	L	L		L	T	L	L	T	T
	18	C	VC		C	M	C	C	M	C	M	M		L	L	L	M	M	D	L	L		L	T	L	L	T	T
	19	C	VC		C	M	C	C	M	C	M	M		L	L	L	M	M	D	L	L		L	T	L	L	T	T
	20	C	VC		C	M	C	C	M	C	M	M		L	L	L	M	M	D	L	L		L	T	L	L	T	T
	21	C	VC		C	M	C	C	M	C	M	M		L	L	L	M	M	D	L	L		L	T	L	L	T	T
	22	C	VC		C	M	C	C	M	C	M	M		L	L	L	M	M	D	L	L		L	T	L	L	T	T
	23	C	VC		C	M	C	C	M	C	M	M		L	L	L	M	M	D	L	L		L	T	L	L	T	T
	24	C	VC		C	M	C	C	M	C	M	M		L	L	L	M	M	D	L	L		L	T	L	L	T	T
CCC	16	M	M		M	C	C	M	M	C	M	M		L	M	L	M	M	M	T	TL		L	T	L	T	T	T
	17	M	M		M	C	C	M	M	C	M	M		L	M	L	M	M	M	T	TL		L	T	L	T	T	T
	18	M	M		M	C	C	M	M	C	M	M		L	M	L	M	M	M	T	TL		L	T	L	T	T	T
	19	M	M		M	C	C	M	M	C	M	M		L	M	L	M	M	M	T	TL		L	T	L	T	T	T
	20	M	M		M	C	C	M	M	C	M	M		L	M	L	M	M	M	T	TL		L	T	L	T	T	T
	21	M	M		M	C	C	M	M	C	M	M		L	M	L	M	M	M	T	TL		L	T	L	T	T	T
	22	M	M		M	C	C	M	M	C	M	M		L	M	L	M	M	M	T	TL		L	T	L	T	T	T
	23	M	M		M	C	C	M	M	C	M	M		L	M	L	M	M	M	T	TL		L	T	L	T	T	T
	24	M	M		M	C	C	M	M	C	M	M		L		L	M	M	M	T	TL		L	T	L	T	T	T
A	19	VC	VC		VC	VC	C	C	C	C	L	L		L	L	M	L	M	D	L	L		L	L	L	L	L	T
	20	VC	VC		VC	VC	C	C	C	C	L	L		L	L	M	L	M	D	L	L		L	L	L	L	L	T
	21	VC	VC		VC	VC	C	C	C	C	L	L		L	L	M	L	M	D	L	L		L	L	L	L	L	T
	22	VC	VC		VC	VC	C	C	C	C	L	L		L	L	M	L	M	D	L	L		L	L	L	L	L	T
	23	VC	VC		VC	VC	C	C	C	C	L	L		L	L	M	L	M	D	L	L		L	L	L	L	L	T
	24	VC	VC		VC	VC	C	C	C	C	L	L		L	L	M	L	M	D	L	L		L	L	L	L	L	T
	25	VC	VC		VC	VC	C	C	C	C	L	L		L	L	M	L	M	D	L	L		L	L	L	L	L	T
	26	VC	VC		VC	VC	C	C	C	C	L	L		L	L	M	L	M	D	L	L		L	L	L	L	L	T
	27	VC	VC		VC	VC	C	C	C	C	L	L		L	L	M	L	M	D	L	L		L	L	L	L	L	T
	28	VC	VC		VC	VC	C	C	C	C	L	L		L	L	M	L	M	D	L	L		L	L	L	L	L	T
	29	VC	VC		VC	VC	C	C	C	C	L	L		L	L	M	L	M	D	L	L		L	L	L	L	L	T
	30	VC	VC		VC	VC	C	C	C	C	L	L		L	L	M	L	M	D	L	L		L	L	L	L	L	T
B	12	M	M		M	M	M	M	S	M	M	D		M	M	D	M	M	D	T	TL		T	T	L	T	T	T
	13	M	M		M	M	M	M	S	M	M	D		M	M	D	M	M	D	T	TL		T	T	L	T	T	T
	14	M	M		M	M	M	M	S	M	M	D		M	M	D	M	M	D	T	TL		T	T	L	T	T	T
	15	M	M		M	M	M	M	S	M	M	D		M	M	D	M	M	D	T	TL		T	T	L	T	T	T
	16	M	M		M	M	M	M	S	M	M	D		M	M	D	M	M	D	T	TL		T	T	L	T	T	T
	29	M	M		M	M	M	M	S	M	M	D		M	M	D	M	M	D	T	TL		T	T	L	T	T	T
	30	M	M		M	M	M	M	S	M	M	D		M	M	D	M	M	D	T	TL		T	T	L	T	T	T
	31	M	M		M	M	M	M	S	M	M	D		M	M	D	M	M	D	T	TL		T	T	L	T	T	T
	32	M	M		M	M	M	M	S	M	M	D		M	M	D	M	M	D	T	TL		T	T	L	T	T	T
	33	M	M		M	M	M	M	S	M	M	D		M	M	D	M	M	D	T	TL		T	T	L	T	T	T
Z	710	S	VS		M	VS	S	M	VS	S	D	D		M	D	D	D	D	D	T	T		T	T	L	T	T	T

ROW No. 8

Mark	Sheet No.	Texture									Color							
		Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc.Adam 6	Mc.Donnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc.Adam 6	Mc.Donnell 7	Smith 8
C	9	C	M		M	M	M	M	M	M	M	L		M	L	M	M	L
	10	C	M		M	M	M	M	M	M	M	L		M	L	M	M	L
	18	C	M		M	M	M	M	M	M	M	L		M	L	M	M	L
	19	C	M		M	M	M	M	M	M	M	L		M	L	M	M	L
	27	C	M		M	M	M	M	M	M	M	L		M	L	M	M	L
	28	C	M		M	M	M	M	M	M	M	L		M	L	M	M	L
	29	C	M		M	M	M	M	M	M	M	L		M	L	M	M	L
	30	C	M		M	M	M	M	M	M	M	L		M	L	M	M	L
	31	C	M		M	M	M	M	M	M	M	L		M	L	M	M	L
D	24	C	C		C	M	C	M	M	C	M	D		L	M	L	M	L
	25	C	C		C	M	C	M	M	C	M	L		L	M	L	M	L
	28	C	C		C	M	C	M	M	C	M	L		L	M	L	M	L
E	16	S	M		S	M	C	M	S	M	M	D		D	M	D	L	D
	17	S	M		S	M	C	M	S	M	M	D		D	M	D	L	D
	18	S	M		S	M	C	M	S	M	M	D		D	M	D	L	D
	19	S	M		S	M	C	M	S	M	M	D		D	M	D	L	D
	20	S	M		S	M	C	M	S	M	M	D		D	M	D	L	D
	21	S	M		S	M	C	M	S	M	M	D		D	M	D	L	D
	22	S	M		S	M	C	M	S	M	M	D		D	M	D	L	D
	23	S	M		S	M	C	M	S	M	M	D		D	M	D	L	D
	24	S	M		S	M	C	M	S	M	M	D		D	M	D	L	D
H	23	S	S		S	S	M	S	S	M	M	D		D	M	M	D	D
	24	S	S		S	S	M	S	S	M	M	D		D	M	M	D	D
	25	S	S		S	S	M	S	S	M	M	D		D	M	M	D	D
	28	S	S		S	S	M	S	S	M	M	D		D	M	M	D	D
	29	S	S		S	S	M	S	S	M	M	D		D	M	M	D	D
	33	S	S		S	S	M	S	S	M	M	D		D	M	M	D	D
	35	S	S		S	S	M	S	S	M	M	D		D	M	M	D	D
	36	S	S		S	S	M	S	S	M	M	D		D	M	M	D	D
I	22	S	VS		S	S	M	S	VS	S	M	D		D	M	D	D	D
	23	S	VS		S	S	M	S	VS	S	M	D		D	M	D	D	D
	24	S	VS		S	S	M	S	VS	S	M	D		D	M	D	D	D
	25	S	VS		S	S	M	S	VS	S	M	D		D	M	D	D	D
	26	S	VS		S	S	M	S	VS	S	M	D		D	M	D	D	D
	27	S	VS		S	S	M	S	VS	S	M	D		D	M	D	D	D
	28	S	VS		S	S	M	S	VS	S	M	D		D	M	D	D	D
	29	S	VS		S	S	M	S	VS	S	M	D		D	M	D	D	D
	30	S	VS		S	S	M	S	VS	S	M	D		D	M	D	D	D
	31	S	VS		S	S	M	S	VS	S	M	D		D	M	D	D	D
	32	S	VS		S	S	M	S	VS	S	M	D		D	M	D	D	D
	33	S	VS		S	S	M	S	VS	S	M	D		D	M	D	D	D
	34	S	VS		S	S	M	S	VS	S	M	D		D	M	D	D	D
	35	S	VS		S	S	M	S	VS	S	M	D		D	M	D	D	D
	36	S	VS		S	S	M	S	VS	S	M	D		D	M	D	D	D
	37	S	VS		S	S	M	S	VS	S	M	D		D	M	D	D	D
Z	605	M	VS		S	S	M	S	S	S	M	D		D	D	D	D	D
	606	M	VS		S	S	M	S	S	S	M	D		D	D	D	D	D
	709	M	VS		S	S	M	S	S	S	M	D		D	D	D	D	D

Sand Blasted.
Exposed 8-13-17.

* Sand Blasted.
† Open Annealed.

* Sand Blasted.
† Open Annealed.
‡ Exposed 8-15-17.

AUPPERLE —
5,17,18 - Failure.
3,14,15 - ,, .
8,19,20,21,22 - Scabby.
25,26 - Rifle Hole.
16 - Failure.
17 - Bent at Top.
19,21,23,24 - Failure.
20 - Bent at Top.
421 - Failure.

— D. M. BUCK —
A – 16,17,18 – Failures.
O – 13,14,15 – ,,
O – 16,19,21,23,24 - ,,
Z – 421 – Failure.

— W. A. COOPER —
Did not make this Inspection.

— W. R. FLEMING —
A – 16,17,18 – Failures.
O – 13,14,15 – ,, .
C – 9-19 – Damaged (Bent)
K – 20,22 – ,, (,,)
T – 20 – ,, (Upper Right Corner Bent)
U – 25,26 – Rifle Hole.
O – 16,19,21,23,24 – Failures.
Z – 421 – Failure.

— J. H. GIBBONEY —
A – 16,17,18 – Failures.
O – 13,14,15 – ,,
O – 16,19,21,23,24 – Failures.
Z – 421 – Failure.

— D. J. Mc. ADAM, JR. —
A – 16,17,18 – Holes near Lower Support.
O – 13,14,15 – Failed below ,, ,, .
OO – 18,21,22 – Lap-over.
K – 20,22 – Bent.
O – 16 – Hole below Lower Support.
O – 17 – Bent above Support.
O – 19 – Hole.
O – 21 – Large Hole.
O – 20,22,23,24 – Bent.
Z – 421 – Hole.

— M. E. Mc. DONNELL —
SS – 15,16,17 – Texture approaching Coarse.
A – 16,17,18 – Failures.
T – 17 – Slightly Bent over Top-Rail.
U – 15 – ,, ,, ,, ,, ,, .
O – 13,14,15 – Failures.
K – 20 – Bent at Upper Right Corner and over Lower Rail.
K – 22 – Bent ,, ,, ,, .
U – 22 – Slightly Bent over Lower Rail.
O – 16 – Failure; one Hole.
O – 17,20 – Bent over Top-Rail.
O – 21,23,24 – Failures; O-19 - Failure, Holes.
O – 22 – Bent.
Z – 421 – Failure; one Hole.

C – 16,17,18 – Failed, large Holes near Bottom.
C – 9 – Somewhat Bent down at Lower Rail, Shallow Dent near Bottom.
O – 13 – Failed, Hole near Bottom.
O – 14 – ,, , Holes and Ragged Edge.
O – 15 – ,, , ,, ,, ,, ,, , Bent down.
OO – 18 to 24 incl. – Original Scabs now Cleaning out.
K – 20 – Bent down, Top and Bottom.
K – 22 – ,, ,, , Bottom.
K – 32 – Dent 1/3 Distance from Bottom.
T – 20 – Bent down at Top.
U – 22 – Slightly Bent down.
U – 25 – Bullet Hole.
U – 26 – ,, ,,

— H. E. SMITH —
O – 20 –
O – 21 –
O – 16 –
O – 22 –
O – 17 –
O – 23,
O – 19 –
Z – 421

PLATE III.
PROC. AM. SOC. TEST. MATS.
VOL. XX, PART I.
REPORT OF COMMITTEE A-5:
CORROSION TESTS.

Weather Clear

Color					Adherence								
5 Gibboney	6 Mc.Adam	7 Mc.Donnell	8 Smith	9 Wheaton	1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 Mc.Adam	7 Mc.Donnell	8 Smith	9 Wheaton
D	M	D	D	D	T	T		T	T	L	T	T	T
D	M	D	D	D	T	T		T	T	L	T	T	T
D	M	D	D	D	T	T		T	T	L	T	T	T
M	M	M	D	D	T	L		T	T	L	T	T	T
M	M	M	D	D	T	L		T	T	L	T	T	T
M	M	D	D	D	T	T		T	T	L	T	T	T
M	M	D	D	D	T	T		T	T	L	T	T	T
L	L	M	M	D	L	L		L	T	L	L	T	T
L	L	M	M	D	L	L		L	T	L	L	T	T
L	L	M	M	D	L	L		L	T	L	L	T	T
L	L	M	M	D	L	L		L	T	L	L	T	T
L	L	M	M	D	L	L		L	T	L	L	T	T
L	L	M	M	D	L	L		L	T	L	L	T	T
L	L	M	M	D	L	L		L	T	L	L	T	T
L	L	M	M	D	L	L		L	T	L	L	T	T
L	L	M	M	D	L	L		L	T	L	L	T	T
M	L	M	M	M	T	TL		L	T	L	T	T	T
M	L	M	M	M	T	TL		L	T	L	T	T	T
M	L	M	M	M	T	TL		L	T	L	T	T	T
M	L	M	M	M	T	TL		L	T	L	T	T	T
M	L	M	M	M	T	TL		L	T	L	T	T	T
M	L	M	M	M	T	TL		L	T	L	T	T	T
M	L	M	M	M	T	TL		L	T	L	T	T	T
M	L	M	M	M	T	TL		L	T	L	T	T	T
	L	M	M	M	T	TL		L	T	L	T	T	T
L	M	L	M	D	L	L		L	L	L	L	L	T
L	M	L	M	D	L	L		L	L	L	L	L	T
L	M	L	M	D	L	L		L	L	L	L	L	T
L	M	L	M	D	L	L		L	L	L	L	L	T
L	M	L	M	D	L	L		L	L	L	L	L	T
L	M	L	M	D	L	L		L	L	L	L	L	T
L	M	L	M	D	L	L		L	L	L	L	L	T
L	M	L	M	D	L	L		L	L	L	L	L	T
L	M	L	M	D	L	L		L	L	L	L	L	T
L	M	L	M	D	L	L		L	L	L	L	L	T
L	M	L	M	D	L	L		L	L	L	L	L	T
L	M	L	M	D	L	L		L	L	L	L	L	T
M	D	M	M	D	T	TL		T	T	L	T	T	T
M	D	M	M	D	T	TL		T	T	L	T	T	T
M	D	M	M	D	T	TL		T	T	L	T	T	T
M	D	M	M	D	T	TL		T	T	L	T	T	T
M	D	M	M	D	T	TL		T	T	L	T	T	T
M	D	M	M	D	T	TL		T	T	L	T	T	T
M	D	M	M	D	T	TL		T	T	L	T	T	T
M	D	M	M	D	T	TL		T	T	L	T	T	T
M	D	M	M	D	T	TL		T	T	L	T	T	T
M	D	M	M	D	T	TL		T	T	L	T	T	T
D	D	D	D	D	T	T		T	T	L	T	T	T

ROW No. 8

Designation		Condition of Rust																										
		Texture									Color									Adherence								
Mark	Sheet No.	1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 Mc.Adam	7 Mc.Donnell	8 Smith	9 Wheaton	1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 Mc.Adam	7 Mc.Donnell	8 Smith	9 Wheaton	1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 Mc.Adam	7 Mc.Donnell	8 Smith	9 Wheaton
C	9	C	M		M	M	M	M	M	M	M	L		M	L	M	M	L	M	T	TL		T	T	L	T	T	T
	10	C	M		M	M	M	M	M	M	M	L		M	L	M	M	L	M	T	TL		T	T	L	T	T	T
	18	C	M		M	M	M	M	M	M	M	L		M	L	M	M	L	M	T	TL		T	T	L	T	T	T
	19	C	M		M	M	M	M	M	M	M	L		M	L	M	M	L	M	T	TL		T	T	L	T	T	T
	27	C	M		M	M	M	M	M	M	M	L		M	L	M	M	L	M	T	TL		T	T	L	T	T	T
	28	C	M		M	M	M	M	M	M	M	L		M	L	M	M	L	M	T	TL		T	T	L	T	T	T
	29	C	M		M	M	M	M	M	M	M	L		M	L	M	M	L	M	T	TL		T	T	L	T	T	T
	30	C	M		M	M	M	M	M	M	M	L		M	L	M	M	L	M	T	TL		T	T	L	T	T	T
	31	C	M		M	M	M	M	M	M	M	L		M	L	M	M	L	M	T	TL		T	T	L	T	T	T
D	24	C	C		C	M	C	M	M	C	M	D		L	M	L	M	L	D	T	L		L	T	L	T	T	T
	25	C	C		C	M	C	M	M	C	M	L		L	M	L	M	L	D	T	L		L	T	L	T	T	T
	28	C	C		C	M	C	M	M	C	M	L		L	M	L	M	L	D	T	L		L	T	L	T	T	T
E	16	S	M		S	M	C	M	S	M	M	D		D	M	D	L	D	D	T	T		T	T	L	T	T	T
	17	S	M		S	M	C	M	S	M	M	D		D	M	D	L	D	D	T	T		T	T	L	T	T	T
	18	S	M		S	M	C	M	S	M	M	D		D	M	D	L	D	D	T	T		T	T	L	T	T	T
	19	S	M		S	M	C	M	S	M	M	D		D	M	D	L	D	D	T	T		T	T	L	T	T	T
	20	S	M		S	M	C	M	S	M	M	D		D	M	D	L	D	D	T	T		T	T	L	T	T	T
	21	S	M		S	M	C	M	S	M	M	D		D	M	D	L	D	D	T	T		T	T	L	T	T	T
	22	S	M		S	M	C	M	S	M	M	D		D	M	D	L	D	D	T	T		T	T	L	T	T	T
	23	S	M		S	M	C	M	S	M	M	D		D	M	D	L	D	D	T	T		T	T	L	T	T	T
	24	S	M		S	M	C	M	S	M	M	D		D	M	D	L	D	D	T	T		T	T	L	T	T	T
H	23	S	S		S	S	M	S	S	M	M	D		D	M	M	D	D	D	T	T		T	T	L	T	T	T
	24	S	S		S	S	M	S	S	M	M	D		D	M	M	D	D	D	T	T		T	T	L	T	T	T
	25	S	S		S	S	M	S	S	M	M	D		D	M	M	D	D	D	T	T		T	T	L	T	T	T
	28	S	S		S	S	M	S	S	M	M	D		D	M	M	D	D	D	T	T		T	T	L	T	T	T
	29	S	S		S	S	M	S	S	M	M	D		D	M	M	D	D	D	T	T		T	T	L	T	T	T
	33	S	S		S	S	M	S	S	M	M	D		D	M	M	D	D	D	T	T		T	T	L	T	T	T
	35	S	S		S	S	M	S	S	M	M	D		D	M	M	D	D	D	T	T		T	T	L	T	T	T
	36	S	S		S	S	M	S	S	M	M	D		D	M	M	D	D	D	T	T		T	T	L	T	T	T
I	22	S	VS		S	S	M	S	VS	S	M	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	23	S	VS		S	S	M	S	VS	S	M	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	24	S	VS		S	S	M	S	VS	S	M	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	25	S	VS		S	S	M	S	VS	S	M	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	26	S	VS		S	S	M	S	VS	S	M	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	27	S	VS		S	S	M	S	VS	S	M	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	28	S	VS		S	S	M	S	VS	S	M	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	29	S	VS		S	S	M	S	VS	S	M	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	30	S	VS		S	S	M	S	VS	S	M	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	31	S	VS		S	S	M	S	VS	S	M	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	32	S	VS		S	S	M	S	VS	S	M	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	33	S	VS		S	S	M	S	VS	S	M	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	34	S	VS		S	S	M	S	VS	S	M	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	35	S	VS		S	S	M	S	VS	S	M	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	36	S	VS		S	S	M	S	VS	S	M	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	37	S	VS		S	S	M	S	VS	S	M	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
Z	605	M	VS		S	S	M	S	S	S	M	D		D	D	D	D	D	T	T	T		T	T	L	T	T	T
	606	M	VS		S	S	M	S	S	S	M	D		D	D	D	D	D	T	T	T		T	T	L	T	T	T
	709	M	VS		S	S	M	S	S	S	M	D		D	D	D	D	D	T	T	T		T	T	L	T	T	T

ROW No. 9

Designation		Condition of Rust																										
		Texture									Color									Adherence								
Mark	Sheet No.	1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 Mc.Adam	7 Mc.Donnell	8 Smith	9 Wheaton	1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 Mc.Adam	7 Mc.Donnell	8 Smith	9 Wheaton	1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 Mc.Adam	7 Mc.Donnell	8 Smith	9 Wheaton
K	20	S	VS		S	S	M	S	S	S	M	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	21	S	VS		S	S	M	S	S	S	M	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	22	S	VS		S	S	M	S	S	S	M	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	23	S	VS		S	S	M	S	S	S	M	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	24	S	VS		S	S	M	S	S	S	M	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	25	S	VS		S	S	M	S	S	S	M	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	26	S	VS		S	S	M	S	S	S	M	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	27	S	VS		S	S	M	S	S	S	M	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	28	S	VS		S	S	M	S	S	S	M	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	29	S	VS		S	S	M	S	S	S	M	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	30	S	VS		S	S	M	S	S	S	M	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	31	S	VS		S	S	M	S	S	S	M	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	32	S	VS		S	S	M	S	S	S	M	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
M	18	M	S		S	M	M	M	S	S	M	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	19	M	S		S	M	M	M	S	S	M	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	20	M	S		S	M	M	M	S	S	M	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	21	M	S		S	M	M	M	S	S	M	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	22	M	S		S	M	M	M	S	S	M	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	23	M	S		S	M	M	M	S	S	M	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	24	M	S		S	M	M	M	S	S	M	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	25	M	S		S	M	M	M	S	S	M	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	26	M	S		S	M	M	M	S	S	M	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	27	M	S		S	M	M	M	S	S	M	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
	28	M	S		S	M	M	M	S	S	M	D		D	M	D	D	D	D	T	T		T	T	L	T	T	T
S	18	C	VC		C	C	C	C	M	C	L	L		L	L	L	L	L	M	L	L		L	T	L	L	T	T
	19	C	VC		C	C	C	C	M	C	L	L		L	L	L	L	L	M	L	L		L	T	L	L	T	T
	20	C	VC		C	C	C	C	M	C	L	L		L	L	L	L	L	M	L	L		L	T	L	L	T	T
	21	C	VC		C	C	C	C	M	C	L	L		L	L	L	L	L	M	L	L		L	T	L	L	T	T
	22	C	VC		C	C	C	C	M	C	L	L		L	L	L	L	L	M	L	L		L	T	L	L	T	T
	23	C	VC		C	C	C	C	M	C	L	L		L	L	L	L	L	M	L	L		L	T	L	L	T	T
	24	C	VC		C	C	C	C	M	C	L	L		L	L	L	L	L	M	L	L		L	T	L	L	T	T
	25	C	VC		C	C	C	C	M	C	L	L		L	L	L	L	L	M	L	L		L	T	L	L	T	T
	26	C	VC		C	C	C	C	M	C	L	L		L	L	L	L	L	M	L	L		L	T	L	L	T	T
	27	C	VC		C	C	C	C	M	C	L	L		L	L	L	L	L	M	L	L		L	T	L	L	T	T
	28	C	VC		C	C	C	C	M	C	L	L		L	L	L	L	L	M	L	L		L	T	L	L	T	T
T	18	S	VS		S	M	M	M	S	M	M	D		D	D	D	D	M	D	T	T		T	T	L	T	T	T
	19	S	VS		S	M	M	M	S	M	M	D		D	D	D	D	M	D	T	T		T	T	L	T	T	T
	20	S	VS		S	M	M	M	S	M	M	D		D	D	D	D	M	D	T	T		T	T	L	T	T	T
	21	S	VS		S	M	M	M	S	M	M	D		D	D	D	D	M	D	T	T		T	T	L	T	T	T
	22	S	VS		S	M	M	M	S	M	M	D		D	D	D	D	M	D	T	T		T	T	L	T	T	T
	23	S	VS		S	M	M	M	S	M	M	D		D	D	D	D	M	D	T	T		T	T	L	T	T	T
	24	S	VS		S	M	M	M	S	M	M	D		D	D	D	D	M	D	T	T		T	T	L	T	T	T
	25	S	VS		S	M	M	M	S	M	M	D		D	D	D	D	M	D	T	T		T	T	L	T	T	T
	26	S	VS		S	M	M	M	S	M	M	D		D	D	D	D	M	D	T	T		T	T	L	T	T	T
	27	S	VS		S	M	M	M	S	M	M	D		D	D	D	D	M	D	T	T		T	T	L	T	T	T
	28	S	VS		S	M	M	M	S	M	M	D		D	D	D	D	M	D	T	T		T	T	L	T	T	T
U	18	S	S		M	M	C	M	M	M	M	D		D	M	M	D	M	M	T	T		T	T	L	T	T	T
	19	S	S		M	M	C	M	M	M	M	D		D	M	M	D	M	M	T	T		T	T	L	T	T	T
	20	S	S		M	M	C	M	M	M	M	D		D	M	M	D	M	M	T	T		T	T	L	T	T	T
	21	S	S		M	M	C	M	M	M	M	D		D	M	M	D	M	M	T	T		T	T	L	T	T	T

ROW No. 10

Designation		Condition of Rust																										
		Texture									Color									Adherence								
Mark	Sheet No.	1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 Mc.Adam	7 Mc.Donnell	8 Smith	9 Wheaton	1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 Mc.Adam	7 Mc.Donnell	8 Smith	9 Wheaton	1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 Mc.Adam	7 Mc.Donnell	8 Smith	9 Wheaton
U	22	M	S		M	C	M	M	S	M	M	D		M	M	M	D	M	D	T	T		T	T	L	T	T	T
	23	M	S		M	C	M	M	S	M	M	D		M	M	M	D	M	D	T	T		T	T	L	T	T	T
	24	M	S		M	C	M	M	S	M	M	D		M	M	M	D	M	D	T	T		T	T	L	T	T	T
	25	M	S		M	C	M	M	S	M	M	D		M	M	M	D	M	D	T	T		T	T	L	T	T	T
	26	M	S		M	C	M	M	S	M	M	D		M	M	M	D	M	D	T	T		T	T	L	T	T	T
	27	M	S		M	C	M	M	S	M	M	D		M	M	M	D	M	D	T	T		T	T	L	T	T	T
	28	M	S		M	C	M	M	S	M	M	D		M	M	M	D	M	D	T	T		T	T	L	T	T	T
V	18	S	S		M	M	M	M	S	M	M	D		M	M	M	D	M	D	T	T		T	T	L	T	T	T
	19	S	S		M	M	M	M	S	M	M	D		M	M	M	D	M	D	T	T		T	T	L	T	T	T
	20	S	S		M	M	M	M	S	M	M	D		M	M	M	D	M	D	T	T		T	T	L	T	T	T
	21	S	S		M	M	M	M	S	M	M	D		M	M	M	D	M	D	T	T		T	T	L	T	T	T
	22	S	S		M	M	M	M	S	M	M	D		M	M	M	D	M	D	T	T		T	T	L	T	T	T
	23	S	S		M	M	M	M	S	M	M	D		M	M	M	D	M	D	T	T		T	T	L	T	T	T
	24	S	S		M	M	M	M	S	M	M	D		M	M	M	D	M	D	T	T		T	T	L	T	T	T
	25	S	S		M	M	M	M	S	M	M	D		M	M	M	D	M	D	T	T		T	T	L	T	T	T
	26	S	S		M	M	M	M	S	M	M	D		M	M	M	D	M	D	T	T		T	T	L	T	T	T
	27	S	S		M	M	M	M	S	M	M	D		M	M	M	D	M	D	T	T		T	T	L	T	T	T
	28	S	S		M	M	M	M	S	M	M	D		M	M	M	D	M	D	T	T		T	T	L	T	T	T
X	18	C	VC		VC	C	C	C	S	M	L	L		L	L	M	L	M	D	L	L		L	T	L	L	T	T
	19	C	VC		VC	C	C	C	S	M	L	L		L	L	M	L	M	D	L	L		L	T	L	L	T	T
	20	C	VC		VC	C	C	C	S	M	L	L		L	L	M	L	M	D	L	L		L	T	L	L	T	T
	21	C	VC		VC	C	C	C	S	M	L	L		L	L	M	L	M	D	L	L		L	T	L	L	T	T
	22	C	VC		VC	C	C	C	S	M	L	L		L	L	M	L	M	D	L	L		L	T	L	L	T	T
	23	C	VC		VC	C	C	C	S	M	L	L		L	L	M	L	M	D	L	L		L	T	L	L	T	T
	24	C	VC		VC	C	C	C	S	M	L	L		L	L	M	L	M	D	L	L		L	T	L	L	T	T
	25	C	VC		VC	C	C	C	S	M	L	L		L	L	M	L	M	D	L	L		L	T	L	L	T	T
	26	C	VC		VC	C	C	C	S	M	L	L		L	L	M	L	M	D	L	L		L	T	L	L	T	T
	27	C	VC		VC	C	C	C	S	M	L	L		L	L	M	L	M	D	L	L		L	T	L	L	T	T
	28	C	VC		VC	C	C	C	S	M	L	L		L	L	M	L	M	D	L	L		L	T	L	L	T	T
O	16	-	VC		VC	VC	C	C	VC	C	-	L		L	D	M	L	M	D	-	L		L	L	L	L	L	T
	17	C	VC		VC	VC	C	C	VC	C	M	L		L	D	M	L	M	D	L	L		L	L	L	L	L	T
	18	C	VC		VC	VC	C	C	VC	C	M	L		L	D	M	L	M	D	L	L		L	L	L	L	L	T
	19	-	VC		VC	VC	C	C	VC	C	-	L		L	D	M	L	M	D	-	L		L	L	L	L	L	T
	20	C	VC		VC	VC	C	C	VC	C	M	L		L	D	M	L	M	D	L	L		L	L	L	L	L	T
	21	-	VC		VC	VC	C	C	VC	C	-	L		L	D	M	L	M	D	-	L		L	L	L	L	L	T
	22	C	VC		VC	VC	C	C	VC	C	M	L		L	D	M	L	M	D	L	L		L	L	L	L	L	T
	23	-	VC		VC	VC	C	C	VC	C	-	L		L	D	M	L	M	D	-	L		L	L	L	L	L	T
	24	-	VC		VC	VC	C	C	VC	C	-	L		L	D	M	L	M	D	-	L		L	L	L	L	L	T
Z	110	S	VS		VS	S	M	S	VS	S	D	D		D	D	D	D	D	D	T	T		T	T	-	T	T	T
	207	S	VS		VS	S	M	S	VS	S	D	D		D	D	D	D	D	D	T	T		T	T	-	T	T	T
	208	S	VS		VS	S	M	S	VS	S	D	D		D	D	D	D	D	D	T	T		T	T	-	T	T	T
	306	S	VS		VS	S	M	S	VS	S	D	D		D	D	D	D	D	D	T	T		T	T	-	T	T	T
	308	S	VS		VS	S	M	S	VS	S	D	D		D	D	D	D	D	D	T	T		T	T	-	T	T	T
	420	-	C		C	C	C	C	M	C	-	L		L	L	L	L	M	D	-	L		L	L	-	L	T	T
	421	-	C		C	C	C	C	M	C	-	L		L	L	L	L	M	D	-	L		L	L	-	L	T	T
	506	S	VS		VS	S	M	M	VS	S	D	D		D	D	D	D	D	D	T	T		T	T	-	T	T	T
	508	S	VS		VS	S	M	M	VS	S	D	D		D	D	D	D	D	D	T	T		T	T	-	T	T	T

— H. E. SMITH —

e.
C-16, 17, 18 - Failed, large Holes near Bottom.
C-9 - Somewhat Bent down at Lower Rail,
Shallow Dent near Bottom.
O-13 - Failed, Hole near Bottom.
O-14 - " , Holes and Ragged Edge.
O-15 - " , " " " " , Bent down.
OO-18 to 24 incl. - Original Scabs now Cleaning out.
K-20 - Bent down, Top and Bottom.
K-22 - " " , Bottom.
K-32 - Dent 1/3 Distance from Bottom.
T-20 - Bent down at Top.
e, Holes.
U-22 - Slightly Bent down.
U-25 - Bullet Hole.
U-26 - " "

O-20 - Badly Bent down at Top.
O-21 - Failed, Very Large Holes.
O-16 - " , Hole near Bottom.
O-22 - Bent down at Bottom.
O-17 - Badly Bent down at Top.
O-23, 24 - Failed, Hole near Bottom
and Bent down at Top.
O-19 - Failed, Hole near Bottom.
Z-421 - Failure, " " " .

— F. B. WHEATON —

A-16, 17, 18 - Failures.
O-13, 14, 15 - "
O-16, 19, 21, 23, 24 - "
Z-421 - Failure.

James H. Gibboney
Chairman Inspection Committee

Date of Inspection May 11, 1920.

ROW No. 1

DESIGNATION		CONDITION OF RUST																										
Mark	Sheet No.	Texture									Color									Adherence								
		1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 Mc.Adam	7 Mc.Donnell	8 Smith	9 Wheaton	1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 Mc.Adam	7 Mc.Donnell	8 Smith	9 Wheaton	1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 Mc.Adam	7 Mc.Donnell	8 Smith	9 Wheaton
AA	21	-	-	-	VC	-	VC	-	C	VC	-	-	-	L	-	M	-	M	M	-	-	-	L	-	L	-	L	L
	22	-	-	-	VC	-	VC	-	C	VC	-	-	-	L	-	M	-	M	M	-	-	-	L	-	L	-	L	L
	23	-	-	-	VC	-	VC	-	C	VC	-	-	-	L	-	M	-	M	M	-	-	-	L	-	L	-	L	L
	24	-	-	-	VC	-	VC	-	C	VC	-	-	-	L	-	M	-	M	M	-	-	-	L	-	L	-	L	L
BB	8	S	S	C	S	M	C	S	S	S	D	D	D	D	D	D	D	D	D	T	TL	L	T	T	L	T	T	T
	9	S	S	C	S	M	C	S	S	S	D	D	D	D	D	D	D	D	D	T	TL	L	T	T	L	T	T	T
	20	M	C	C	C	C	C	M	S	M	M	M	D	L	M	D	M	D	D	L	L	L	L	L	L	L	T	T
	21	M	C	C	C	C	C	M	S	M	M	M	D	L	M	D	M	D	D	L	L	L	L	L	L	L	T	T
CC	15	M	M	C	M	C	C	C	M	M	M	M	D	D	M	D	M	M	D	T	L	L	L	T	L	L	L	T
	16	M	M	C	M	C	C	C	M	M	M	M	D	D	M	D	M	M	D	T	L	L	L	T	L	L	L	T
	17	M	M	C	M	C	C	C	M	M	M	M	D	D	M	D	M	M	D	T	L	L	L	T	L	L	L	T
	18	M	M	C	M	C	C	C	M	M	M	M	D	D	M	D	M	M	D	T	L	L	L	T	L	L	L	T
DD	25	C	C	VC	VC	VC	VC	C	C	C	M	L	L	L	M	M	M	M	M	T	L	L	L	L	L	L	L	L
	26	C	C	VC	VC	VC	VC	C	C	C	M	L	L	L	M	M	M	M	M	T	L	L	L	L	L	L	L	L
	27	C	C	VC	VC	VC	VC	C	C	C	M	L	L	L	M	M	M	M	M	T	L	L	L	L	L	L	L	L
	28	C	C	VC	VC	VC	VC	C	C	C	M	L	L	L	M	M	M	M	M	T	L	L	L	L	L	L	L	L
EE⊕	13	S	S	M	S	M	M	S	S	S	D	D	D	D	D	D	D	D	D	T	TL	T	T	T	L	T	L	T
	14	S	S	M	S	M	M	S	S	S	D	D	D	D	D	D	D	D	D	T	TL	T	T	T	L	T	L	T
	15	S	S	M	S	M	M	S	S	S	D	D	D	D	D	D	D	D	D	T	TL	T	T	T	L	T	L	T
	16	S	S	M	S	M	M	S	S	S	D	D	D	D	D	D	D	D	D	T	TL	T	T	T	L	T	L	T
HH	19	S	S	S	VS	S	M	VS	VS	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
	20	S	S	S	VS	S	M	VS	VS	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
	21	S	S	S	VS	S	M	VS	VS	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
	22	S	S	S	VS	S	M	VS	VS	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
II	20	S	VS	S	VS	VS	M	VS	VS	VS	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
	21	S	VS	S	VS	VS	M	VS	VS	VS	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
	22	S	VS	S	VS	VS	M	VS	VS	VS	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
	23	S	VS	S	VS	VS	M	VS	VS	VS	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
KK	6	S	VS	S	VS	S	M	VS	VS	VS	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
	7	S	VS	S	VS	S	M	VS	VS	VS	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
	8	S	VS	S	VS	S	M	VS	VS	VS	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
	27	S	VS	S	VS	S	M	VS	VS	VS	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
MM⊕	29	C	C	C	C	C	C	M	M	C	M	M	M	M	M	D	M	M	D	T	L	TL	L	T	L	L	L	L
	30	C	C	C	C	C	C	M	M	C	M	M	M	M	M	D	M	M	D	T	L	TL	L	T	L	L	L	L
	31	C	C	C	C	C	C	M	M	C	M	M	M	M	M	D	M	M	D	T	L	TL	L	T	L	L	L	L
	32	C	C	C	C	C	C	M	M	C	M	M	M	M	M	D	M	M	D	T	L	TL	L	T	L	L	L	L
SS	29	-	VC	-	VC	VC	VC	VC	VC	VC	-	L	-	L	L	M	L	L	D	-	L	-	L	L	L	L	L	L
	30	-	VC	-	VC	VC	VC	VC	VC	VC	-	L	-	L	L	M	L	L	D	-	L	-	L	L	L	L	L	L
	31	-	VC	-	VC	VC	VC	VC	VC	VC	-	L	-	L	L	M	L	L	D	-	L	-	L	L	L	L	L	L
	32	-	VC	-	VC	VC	VC	VC	VC	VC	-	L	-	L	L	M	L	L	D	-	L	-	L	L	L	L	L	L
TT	29	S	VS	S	VS	S	M	S	VS	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
	30	S	VS	S	VS	S	M	S	VS	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
	31	S	VS	S	VS	S	M	S	VS	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
	32	S	VS	S	VS	S	M	S	VS	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
UU	29	S	S	S	S	S	M	S	S	S	D	D	D	D	M	D	D	M	D	T	T	T	T	T	L	T	L	T
	30	S	S	S	S	S	M	S	S	S	D	D	D	D	M	D	D	M	D	T	T	T	T	T	L	T	L	T
	31	S	S	S	S	S	M	S	S	S	D	D	D	D	M	D	D	M	D	T	T	T	T	T	L	T	L	T
	32	S	S	S	S	S	M	S	S	S	D	D	D	D	M	D	D	M	D	T	T	T	T	T	L	T	L	T
YY	39	S	S	S	S	S	M	S	S	M	D	D	D	D	M	D	D	M	D	T	T	T	T	T	L	T	L	T
	40	S	S	S	S	S	M	S	S	M	D	D	D	D	M	D	D	M	D	T	T	T	T	T	L	T	L	T
	41	S	S	S	S	S	M	S	S	M	D	D	D	D	M	D	D	M	D	T	T	T	T	T	L	T	L	T
	42	S	S	S	S	S	M	S	S	M	D	D	D	D	M	D	D	M	D	T	T	T	T	T	L	T	L	T
XX	29	VC	VC	-	VC	VC	VC	VC	VC	VC	L	L	-	L	L	M	L	L	M	L	L	-	L	L	L	L	L	L
	30	VC	VC	-	VC	VC	VC	VC	VC	VC	L	L	-	L	L	M	L	L	M	L	L	-	L	L	L	L	L	L
	31	VC	VC	-	VC	VC	VC	VC	VC	VC	L	L	-	L	L	M	L	L	M	L	L	-	L	L	L	L	L	L
	32	VC	VC	-	VC	VC	VC	VC	VC	VC	L	L	-	L	L	M	L	L	M	L	L	-	L	L	L	L	L	L
OO	25	VC	C	VC	VC	C		VC	C	C	L	L	L	L	M		L	L	M	L	L	L	L	L		L	L	L
	26	VC	C	VC	VC	C		VC	C	C	L	L	L	L	M		L	L	M	L	L	L	L	L		L	L	L
	27	VC	C	VC	VC	C		VC	C	C	L	L	L	L	M		L	L	M	L	L	L	L	L		L	L	L
	28	VC	C	VC	VC	C		VC	C	C	L	L	L	L	M		L	L	M	L	L	L	L	L		L	L	L
CCC	1	S	M	S	S	S	M	S	S	M	D	D	D	D	D	D	D	D	D	T	TL	T	T	T	L	T	T	T
	2	S	M	S	S	S	M	S	S	M	D	D	D	D	D	D	D	D	D	T	TL	T	T	T	L	T	T	T
	3	S	M	S	S	S	M	S	S	M	D	D	D	D	D	D	D	D	D	T	TL	T	T	T	L	T	T	T
	4	S	M	S	S	S	M	S	S	M	D	D	D	D	D	D	D	D	D	T	TL	T	T	T	L	T	T	T
ZZ	8	-	-	-	VC	-	VC	-	C	C	-	-	-	L	-	M	-	L	M	-	-	-	L	-	L	-	L	L
	10	-	-	-	VC	-	VC	-	C	C	-	-	-	L	-	M	-	L	M	-	-	-	L	-	L	-	L	L
	14	-	-	-	VC	-	VC	-	C	C	-	-	-	L	-	M	-	L	M	-	-	-	L	-	L	-	L	L
	107	VS	S	S	VS	S	M	M	VS	VS	D	D	D	D	M	D	M	M	D	T	T	T	T	T	L	L	T	T
	310	VS	S	VS	VS	VS	M	S	VS	VS	D	D	D	D	D	D	D	M	D	T	T	T	T	T	L	T	T	T
	311	VS	VS	VS	VS	VS	M	S	VS	VS	D	D	D	D	D	D	D	M	D	T	T	T	T	T	L	T	T	T

⊕ Open Annealed.

ROW No. 2

DESIGNATION		CONDITION OF RUST																										
Mark	Sheet No.	Texture									Color									Adherence								
		1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 Mc.Adam	7 Mc.Donnell	8 Smith	9 Wheaton	1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 Mc.Adam	7 Mc.Donnell	8 Smith	9 Wheaton	1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 Mc.Adam	7 Mc.Donnell	8 Smith	9 Wheaton
A	31	-	-	-	VC	-	VC	-	-	VC	-	-	-	L	-	M	-	-	M	-	-	-	L	-	L	-	-	L
	32	-	-	-	VC	-	VC	-	-	VC	-	-	-	L	-	M	-	-	M	-	-	-	L	-	L	-	-	L
	33	-	-	-	VC	-	VC	-	-	VC	-	-	-	L	-	M	-	-	M	-	-	-	L	-	L	-	-	L
	34	-	-	-	VC	-	VC	-	-	VC	-	-	-	L	-	M	-	-	M	-	-	-	L	-	L	-	-	L
B	17	-	C	C	C	M	C	M	M	C	-	D	M	L	D	D	M	M	D	-	L	L	L	T	L	L	L	T
	18	-	C	C	C	M	C	M	M	C	-	D	M	L	D	D	M	M	D	-	L	L	L	T	L	L	L	T
	19	M	C	C	C	M	C	M	M	C	M	D	M	L	D	D	M	M	D	T	L	L	L	T	L	L	L	T
	20	M	C	C	C	M	C	M	M	C	M	D	M	L	D	D	M	M	D	T	L	L	L	T	L	L	L	T
C	11	-	C	C	C	M	C	C	M	C	-	D	M	M	D	D	M	M	D	-	L	L	L	T	L	L	L	T
	12	M	C	C	C	M	C	C	M	C	M	D	M	M	D	D	M	M	D	T	L	L	L	T	L	L	L	T
	13	-	C	C	C	M	C	C	M	C	-	D	M	M	D	D	M	M	D	-	L	L	L	T	L	L	L	T
	14	-	C	C	C	M	C	C	M	C	-	D	M	M	D	D	M	M	D	-	L	L	L	T	L	L	L	T
D	30	-	-	-	VC	-	VC	-	VC	VC	-	-	-	L	-	M	-	L	M	-	-	-	L	-	L	-	L	L
	31	-	-	-	VC	-	VC	-	VC	VC	-	-	-	L	-	M	-	L	M	-	-	-	L	-	L	-	L	L
	33	-	-	-	VC	-	VC	-	VC	VC	-	-	-	L	-	M	-	L	M	-	-	-	L	-	L	-	L	L
	34	-	-	-	VC	-	VC	-	VC	VC	-	-	-	L	-	M	-	L	M	-	-	-	L	-	L	-	L	L
E	25	-	M	-	M	C	C	M	M	M	-	D	-	D	D	D	D	M	D	-	T	-	T	T	L	L	L	T
	26	-	M	-	M	C	C	M	M	M	-	D	-	D	D	D	D	M	D	-	T	-	T	T	L	L	L	T
	27	-	M	-	M	C	C	M	M	M	-	D	-	D	D	D	D	M	D	-	T	-	T	T	L	L	L	T
	28	-	M	-	M	C	C	M	M	M	-	D	-	D	D	D	D	M	D	-	T	-	T	T	L	L	L	T
H	38	S	S	S	S	S	M	S	S	M	M	D	D	D	D	D	D	M	D	T	T	T	T	T	L	T	L	T
	40	S	S	S	S	S	M	S	S	M	M	D	D	D	D	D	D	M	D	T	T	T	T	T	L	T	L	T
	41	S	S	S	S	S	M	S	S	M	M	D	D	D	D	D	D	M	D	T	T	T	T	T	L	T	L	T
	42	S	S	S	S	S	M	S	S	M	M	D	D	D	D	D	D	M	D	T	T	T	T	T	L	T	L	T
I	38	S	VS	S	S	VS	M	VS	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	39	S	VS	S	S	VS	M	VS	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	40	S	VS	S	S	VS	M	VS	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	41	-	VS	S	S	VS	M	VS	S	S	T	D	D	D	D	D	D	D	D	-	T	T	T	T	L	T	L	T
K	33	S	VS	S	S	VS	M	VS	VS	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
	34	S	VS	S	S	VS	M	VS	VS	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
	35	S	VS	S	S	VS	M	VS	VS	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
	36	S	VS	S	S	VS	M	VS	VS	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
M	29	C	M	M	M	M	C	M	M	M	M	D	M	M	D	D	M	M	D	T	TL	T	T	T	L	L	L	T
	30	C	M	M	M	M	C	M	M	M	M	D	M	M	D	D	M	M	D	T	TL	T	T	T	L	L	L	T
	31	C	M	M	M	M	C	M	M	M	M	D	M	M	D	D	M	M	D	T	TL	T	T	T	L	L	L	T
	32	-	M	M	M	M	C	M	M	M	-	D	M	M	D	D	M	M	D	-	TL	T	T	T	L	L	L	T
S	29	-	-	-	VC	-	VC	-	-	VC	-	-	-	L	-	M	-	-	M	-	-	-	L	-	L	-	-	L
	30	-	-	-	VC	-	VC	-	-	VC	-	-	-	L	-	M	-	-	M	-	-	-	L	-	L	-	-	L
	31	-	-	-	VC	-	VC	-	-	VC	-	-	-	L	-	M	-	-	M	-	-	-	L	-	L	-	-	L
	32	-	-	-	VC	-	VC	-	-	VC	-	-	-	L	-	M	-	-	M	-	-	-	L	-	L	-	-	L
T	29	S	S	M	S	S	MC	M	M	M	D	D	D	D	D	D	D	M	D	T	T	TL	T	T	L	L	L	T
	30	S	S	M	S	S	MC	M	M	M	D	D	D	D	D	D	D	M	D	T	T	TL	T	T	L	L	L	T
	31	S	S	M	S	S	MC	M	M	M	D	D	D	D	D	D	D	M	D	T	T	TL	T	T	L	L	L	T
	32	-	S	M	S	S	MC	M	M	M	-	D	D	D	D	D	D	M	D	-	T	TL	T	T	L	L	L	T
U	29	-	S	M	S	S	MC	M	M	M	-	D	M	D	D	D	D	M	D	-	T	TL	T	T	-	L	L	T
	30	-	S	M	S	S	MC	M	M	M	-	D	M	D	D	D	D	M	D	-	T	TL	T	T	-	L	L	T
	31	S	S	M	S	S	MC	M	M	M	D	D	M	D	D	D	D	M	D	T	T	TL	T	T	-	L	L	T
	32	S	S	M	S	S	MC	M	M	M	D	D	M	D	D	D	D	M	D	T	T	TL	T	T	-	L	L	T
V	29	-	S	M	M	M	C	M	M	M	-	D	D	M	D	D	D	M	D	-	T	TL	L	T	L	L	L	T
	30	-	S	M	M	M	C	M	M	M	-	D	D	M	D	D	D	M	D	-	T	TL	L	T	L	L	L	T
	31	-	S	M	M	M	C	M	M	M	-	D	D	M	D	D	D	M	D	-	T	TL	L	T	L	L	L	T
	32	-	S	M	M	M	C	M	M	M	-	D	D	M	D	D	D	M	D	-	T	TL	L	T	L	L	L	T
X	29	-	-	-	-	-	VC	-	-	VC	-	-	-	-	-	M	-	-	M	-	-	-	-	-	L	-	-	L
	30	-	-	-	-	-	VC	-	-	VC	-	-	-	-	-	M	-	-	M	-	-	-	-	-	L	-	-	L
	31	-	-	-	-	-	VC	-	-	VC	-	-	-	-	-	M	-	-	M	-	-	-	-	-	L	-	-	L
	32	-	-	-	-	-	VC	-	-	VC	-	-	-	-	-	M	-	-	M	-	-	-	-	-	L	-	-	L
O	25	-	-	-	-	-	VC	-	-	VC	-	-	-	-	-	M	-	-	M	-	-	-	-	-	L	-	-	L
	26	-	-	-	-	-	VC	-	-	VC	-	-	-	-	-	M	-	-	M	-	-	-	-	-	L	-	-	L
	27	-	-	-	-	-	VC	-	-	VC	-	-	-	-	-	M	-	-	M	-	-	-	-	-	L	-	-	L
	28	-	-	-	-	-	VC	-	-	VC	-	-	-	-	-	M	-	-	M	-	-	-	-	-	L	-	-	L
Z	6	-	-	-	VC	-	-	-	-	VC	-	-	-	L	-	-	-	-	M	-	-	-	L	-	-	-	-	L
	7	-	-	-	VC	-	-	-	-	VC	-	-	-	L	-	-	-	-	M	-	-	-	L	-	-	-	-	L
	11	-	-	-	VC	-	-	-	-	VC	-	-	-	L	-	-	-	-	M	-	-	-	L	-	-	-	-	L
	111	M	S	S	S	S	-	S	S	M	M	D	D	D	D	-	D	M	D	T	T	T	T	T	-	L	L	T
	112	M	S	S	S	S	-	S	S	M	M	D	D	D	D	-	D	M	D	T	T	T	T	T	-	L	L	T
	113	M	S	S	S	S	-	S	S	M	M	D	D	D	D	-	D	M	D	T	T	T	T	T	-	L	L	T
	209	VS	VS	VS	VS	S	-	VS	S	S	D	D	D	D	D	-	D	M	D	T	T	T	T	T	-	T	L	T
	213	VS	VS	VS	VS	S	-	VS	S	S	D	D	D	D	D	-	D	M	D	T	T	T	T	T	-	T	L	T
	214	VS	VS	VS	VS	S	-	VS	S	S	D	D	D	D	D	-	D	M	D	T	T	T	T	T	-	T	L	T
	310	VS	VS	VS	VS	S	-	VS	S	S	D	D	D	D	D	-	D	M	D	T	T	T	T	T	-	T	L	T

ROW No. 3

DESIGNATION		CONDITION OF RUST																										
Mark	Sheet No.	Texture									Color									Adherence								
		1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 Mc.Adam	7 Mc.Donnell	8 Smith	9 Wheaton	1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 Mc.Adam	7 Mc.Donnell	8 Smith	9 Wheaton	1 Aupperle	2 Buck	3 Cooper	4 Fleming	5 Gibboney	6 Mc.Adam	7 Mc.Donnell	8 Smith	9 Wheaton
AA	25	-	-	-	VC	-	VC	-	-	VC	-	-	-	L	-	M	-	-	M	-	-	-	L	-	L	-	-	L
	26	-	-	-	VC	-	VC	-	-	VC	-	-	-	L	-	M	-	-	M	-	-	-	L	-	L	-	-	L
	27	-	-	-	VC	-	VC	-	-	VC	-	-	-	L	-	M	-	-	M	-	-	-	L	-	L	-	-	L
	28	-	-	-	VC	-	VC	-	-	VC	-	-	-	L	-	M	-	-	M	-	-	-	L	-	L	-	-	L
	29	-	-	-	VC	-	VC	-	-	VC	-	-	-	L	-	M	-	-	M	-	-	-	L	-	L	-	-	L
	30	-	-	-	VC	-	VC	-	-	VC	-	-	-	L	-	M	-	-	M	-	-	-	L	-	L	-	-	L
AA⊕	50	-	-	-	VC	-	VC	-	-	VC	-	-	-	L	-	M	-	-	M	-	-	-	L	-	L	-	-	L
	51	-	-	-	VC	-	VC	-	-	VC	-	-	-	L	-	M	-	-	M	-	-	-	L	-	L	-	-	L
	52	-	-	-	VC	-	VC	-	-	VC	-	-	-	L	-	M	-	-	M	-	-	-	L	-	L	-	-	L
	53	-	-	-	VC	-	VC	-	-	VC	-	-	-	L	-	M	-	-	M	-	-	-	L	-	L	-	-	L
	54	-	-	-	VC	-	VC	-	-	VC	-	-	-	L	-	M	-	-	M	-	-	-	L	-	L	-	-	L
	55	-	-	-	VC	-	VC	-	-	VC	-	-	-	L	-	M	-	-	M	-	-	-	L	-	L	-	-	L
	56	-	-	-	VC	-	VC	-	-	VC	-	-	-	L	-	M	-	-	M	-	-	-	L	-	L	-	-	L
BB	22	C	C	C	C	C	VC	VC	C	C	L	L	L	L	D	M	M	L	M	T	L	L	L	T	L	L	L	L
	23	C	C	C	C	C	VC	VC	C	C	L	L	L	L	D	M	M	L	M	T	L	L	L	T	L	L	L	L
	24	C	C	C	C	M	VC	VC	C	C	L	L	L	L	M	M	M	L	M	T	L	L	L	T	L	L	L	L
	40	M	S	M	M	M	C	M	M	M	D	D	M	D	M	D	M	M	D	T	T	TL	L	T	L	L	L	T
	41	M	S	M	M	M	C	M	M	M	D	D	M	D	M	D	M	M	D	T	T	TL	L	T	L	L	L	T
BB⊕	33	M	S	M	M	M	C	M	M	M	D	D	M	D	D	D	M	M	D	T	T	TL	L	T	L	L	L	T
	34	M	S	M	M	M	C	M	M	M	D	D	M	D	D	D	M	M	D	T	T	TL	L	T	L	L	L	T
	35	M	S	M	M	M	C	M	M	M	D	D	M	D	D	D	M	M	D	T	T	TL	L	T	L	L	L	T
	36	M	S	M	M	M	C	M	M	M	D	D	M	D	D	D	M	M	D	T	T	TL	L	T	L	L	L	T
	50	M	S	M	M	M	C	M	M	M	D	D	M	D	D	D	M	M	D	T	T	TL	L	T	L	L	L	T
	51	M	S	M	M	M	C	M	M	M	D	D	M	D	D	D	M	M	D	T	T	TL	L	T	L	L	L	T
	52	M	S	M	M	M	C	M	M	M	D	D	M	D	D	D	M	M	D	T	T	TL	L	T	L	L	L	T
	53	M	S	M	M	M	C	M	M	M	D	D	M	D	D	D	M	M	D	T	T	TL	L	T	L	L	L	T
CC	7	C	C	C	C	C	VC	C	M	M	M	L	M	M	M	M	M	M	M	L	L	L	L	L	L	L	L	L
	19	C	C	C	C	C	VC	VC	C	C	M	L	M	M	M	M	M	L	M	L	L	L	L	L	L	L	L	L
CC⊕	31	C	C	C	C	C	VC	VC	C	C	M	L	M	M	M	M	M	L	M	L	L	L	L	L	L	L	L	L
	32	C	C	C	C	C	VC	VC	C	C	M	L	M	M	M	M	M	L	M	L	L	L	L	L	L	L	L	L
	33	C	C	C	C	C	VC	VC	C	C	M	L	M	M	M	M	M	L	M	L	L	L	L	L	L	L	L	T
	34	C	C	C	C	C	VC	VC	C	C	M	L	M	M	M	M	M	L	M	L	L	L	L	L	L	L	L	T
	35	C	C	C	C	C	VC	VC	C	C	M	L	M	M	M	M	M	L	M	L	L	L	L	L	L	L	L	T
	36	C	C	C	C	C	VC	VC	C	C	M	L	M	M	M	M	M	L	M	L	L	L	L	L	L	L	L	T
DD	8	VC	C	VC	VC	VC	VC	VC	C	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
	9	VC	C	VC	VC	VC	VC	VC	C	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
	10	VC	C	VC	VC	VC	VC	VC	C	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
	29	VC	C	VC	VC	VC	VC	VC	C	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
	30	VC	C	VC	VC	VC	VC	VC	C	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
	31	VC	C	VC	VC	VC	VC	VC	C	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
DD⊕	47	VC	C	VC	VC	VC	VC	VC	C	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
	48	VC	C	VC	VC	VC	VC	VC	C	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
	49	VC	C	VC	VC	VC	VC	VC	C	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
	54	VC	C	VC	VC	VC	VC	VC	C	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
	55	VC	C	VC	VC	VC	VC	VC	C	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
	56	VC	C	VC	VC	VC	VC	VC	C	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
	57	VC	C	VC	VC	VC	VC	VC	C	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
	58	VC	C	VC	VC	VC	VC	VC	C	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
EE†	17	S	C	S	S	S	C	S	S	S	D	D	D	D	D	D	D	D	D	T	TL	T	T	T	L	T	L	T
	18	S	S	S	S	S	C	S	S	S	D	D	D	D	D	D	D	D	D	T	TL	T	T	T	L	T	L	T
EE⊕†	31	S	S	S	S	S	C	S	S	S	D	D	D	D	D	D	D	D	D	T	TL	T	T	T	L	T	L	T
	32	S	S	S	S	S	C	S	S	S	D	D	D	D	D	D	D	D	D	T	TL	T	T	T	L	T	L	T
	33	S	S	S	S	S	C	S	S	S	D	D	D	D	D	D	D	D	D	T	TL	T	T	T	L	T	L	T
	34	S	S	S	S	S	C	S	S	S	D	D	D	D	D	D	D	D	D	T	TL	T	T	T	L	T	L	T
	35	S	S	S	S	S	C	S	S	S	D	D	D	D	D	D	D	D	D	T	TL	T	T	T	L	T	L	T
	36	S	S	S	S	S	C	S	S	S	D	D	D	D	D	D	D	D	D	T	TL	T	T	T	L	T	L	T
HH	23	S	S	S	S	S	C	VS	S	M	D	D	D	D	D	D	D	M	D	T	T	T	T	T	L	T	L	T
	24	S	S	S	S	S	C	VS	S	M	D	D	D	D	D	D	D	M	D	T	T	T	T	T	L	T	L	T
	25	S	S	S	S	S	C	VS	S	M	D	D	D	D	D	D	D	M	D	T	T	T	T	T	L	T	L	T
	26	S	S	S	S	S	C	VS	S	M	D	D	D	D	D	D	D	M	D	T	T	T	T	T	L	T	L	T
HH⊕	43	S	S	S	S	S	C	VS	S	M	D	D	D	D	D	D	D	M	D	T	T	T	T	T	L	T	L	T
	44	S	S	S	S	S	C	VS	S	M	D	D	D	D	D	D	D	M	D	T	T	T	T	T	L	T	L	T
	45	S	S	S	S	S	C	VS	S	M	D	D	D	D	D	D	D	M	D	T	T	T	T	T	L	T	L	T
	46	S	S	S	S	S	C	VS	S	M	D	D	D	D	D	D	D	M	D	T	T	T	T	T	L	T	L	T
	47	S	S	S	S	S	C	VS	S	M	D	D	D	D	D	D	D	M	D	T	T	T	T	T	L	T	L	T
	48	S	S	S	S	S	C	VS	S	M	D	D	D	D	D	D	D	M	D	T	T	T	T	T	L	T	L	T
	49	S	S	S	S	S	C	VS	S	M	D	D	D	D	D	D	D	M	D	T	T	T	T	T	L	T	L	T
II	24	VS	VS	VS	S	S	M	VS	S	VS	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	25	VS	VS	VS	S	S	M	VS	S	VS	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	27	VS	VS	VS	S	S	M	VS	S	VS	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	28	VS	VS	VS	S	S	M	VS	S	VS	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	29	VS	VS	VS	S	S	M	VS	S	VS	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T

⊕ Sand Blasted.
† Open Annealed.

CONDITION OF RUST.

Texture	Color	Adherence
VS—Very Smooth	L—Light	T—Tight
S—Smooth	M—Medium	L—Loose.
M—Medium	D—Dark	
C—Coarse		
VC—Very Coarse		

— INSPECTION COMMITTEE —

J. H. Gibboney, Chairman — Norfolk & Western Ry. Co.
J. A. Aupperle — American Rolling Mill Co.
D. M. Buck — American Sheet & Tin Plate Co.
W. A. Cooper — Alan Wood Iron & Steel Co.
W. R. Fleming — The Andrews Steel Co.
D. J. Mc.Adam, Jr. — U.S. Navy, Bureau Steam Engineering.
M. E. Mc.Donnell — Pennsylvania Railroad Co.
H. E. Smith — New York Central Railroad Co.
F. B. Wheaton — U.S. Army, Quartermaster's Corps.

— J. A. AUPPERLE —

NOTES:

AA-21,22,23,24 Failure.	O-25,26,27,28-Failure.	Y-7,8,9 Failure.
SS-29,30,31,32- "	Z-6,7,11, "	X-33 to 42 incl. "
ZZ-8-10-14- "	AA⊕ 50,51,52,53,54,55,56 Failure.	U-40,41- "
A-31,32,33,34 "	AA-25,26,27,28,29,30- "	V-36,37,39,42 "
B-17, 18 "	XX-29,30,31,32,41 "	Z-422,423,424 "
C-11,13,14 "	SS-33,35,39,40 "	O-29 to 36 incl. "
D-30,31,33,34 "	A-35 to 47 incl. "	
E-25,26,27,28 "	B-35,36,37,38- "	
M-32- "	C-20,21,22,32,34,35 "	
S-29,30,31,32 "	D-35,36,38,39,40 "	
T-32- "	E-29 to 36 incl. "	
U-29,30- "	M-36,42 "	
V-29 "	S-33 to 42 incl. "	
X-29,30,31,32 "	T-33,35 to 39 incl. "	

TABLE IV.—RESULTS OF INSPECTION OF CORROSION TEST SHEETS, AT PITTSBURGH, PA., MAY 11, 1920.

AMERICAN SOCIETY FOR TESTING MATERIALS
COMMITTEE A-5 ON CORROSION OF IRON AND STEEL
TESTS OF UNCOATED SHEETS
PITTSBURGH, PA.

EXPOSED DECEMBER 12, 1916

Date of Inspection *May 11, 1920.*

Weather *Heav*

CONDITION OF RUST

ROW No. 3

Mark	Sheet No.	Texture: Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc. Adam 6	Mc. Donnell 7	Smith 8	Wheaton 9	Color: Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc. Adam 6	Mc. Donnell 7	Smith 8	Wheaton 9	Adherence: Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc. Adam 6	Mc. Donnell 7	Smith 8	Wheaton 9
	25	–	–	–	VC	–	VC	–	–	VC	–	–	–	L	–	M	–	–	M	–	–	–	L	–	L	–	–	L
	26	–	–	–	VC	–	VC	–	–	VC	–	–	–	L	–	M	–	–	M	–	–	–	L	–	L	–	–	L
	27	–	–	–	VC	–	VC	–	–	VC	–	–	–	L	–	M	–	–	M	–	–	–	L	–	L	–	–	L
	28	–	–	–	VC	–	VC	–	–	VC	–	–	–	L	–	M	–	–	M	–	–	–	L	–	L	–	–	L
	29	–	–	–	VC	–	VC	–	–	VC	–	–	–	L	–	M	–	–	M	–	–	–	L	–	L	–	–	L
	30	–	–	–	VC	–	VC	–	–	VC	–	–	–	L	–	M	–	–	M	–	–	–	L	–	L	–	–	L
	50	–	–	–	VC	–	VC	–	–	VC	–	–	–	L	–	M	–	–	M	–	–	–	L	–	L	–	–	L
	51	–	–	–	VC	–	VC	–	–	VC	–	–	–	L	–	M	–	–	M	–	–	–	L	–	L	–	–	L
	52	–	–	–	VC	–	VC	–	–	VC	–	–	–	L	–	M	–	–	M	–	–	–	L	–	L	–	–	L
	53	–	–	–	VC	–	VC	–	–	VC	–	–	–	L	–	M	–	–	M	–	–	–	L	–	L	–	–	L
	54	–	–	–	VC	–	VC	–	–	VC	–	–	–	L	–	M	–	–	M	–	–	–	L	–	L	–	–	L
	55	–	–	–	VC	–	VC	–	–	VC	–	–	–	L	–	M	–	–	M	–	–	–	L	–	L	–	–	L
	56	–	–	–	VC	–	VC	–	–	VC	–	–	–	L	–	M	–	–	M	–	–	–	L	–	L	–	–	L
	22	C	C	C	C	C	VC	VC	C	C	L	L	L	L	D	M	M	L	M	T	L	L	L	T	L	L	L	L
	23	C	C	C	C	C	VC	VC	C	C	L	L	L	L	D	M	M	L	M	T	L	L	L	T	L	L	L	L
	24	C	C	C	C	M	VC	VC	C	C	L	L	L	L	M	M	M	L	M	T	L	L	L	T	L	L	L	L
	40	M	S	M	M	M	C	M	M	M	D	D	M	D	M	D	M	M	D	T	T	TL	L	T	L	L	L	T
	41	M	S	M	M	M	C	M	M	M	D	D	M	D	M	D	M	M	D	T	T	TL	L	T	L	L	L	T
	33	M	S	M	M	M	C	M	M	M	D	D	M	D	D	D	M	M	D	T	T	TL	L	T	L	L	L	T
	34	M	S	M	M	M	C	M	M	M	D	D	M	D	D	D	M	M	D	T	T	TL	L	T	L	L	L	T
	35	M	S	M	M	M	C	M	M	M	D	D	M	D	D	D	M	M	D	T	T	TL	L	T	L	L	L	T
	36	M	S	M	M	M	C	M	M	M	D	D	M	D	D	D	M	M	D	T	T	TL	L	T	L	L	L	T
	50	M	S	M	M	M	C	M	M	M	D	D	M	D	D	D	M	M	D	T	T	TL	L	T	L	L	L	T
	51	M	S	M	M	M	C	M	M	M	D	D	M	D	D	D	M	M	D	T	T	TL	L	T	L	L	L	T
	52	M	S	M	M	M	C	M	M	M	D	D	M	D	D	D	M	M	D	T	T	TL	L	T	L	L	L	T
	53	M	S	M	M	M	C	M	M	M	D	D	M	D	D	D	M	M	D	T	T	TL	L	T	L	L	L	T
	7	C	C	C	C	C	VC	C	M	M	M	L	M	M	M	M	M	M	M	L	L	L	L	L	L	L	L	L
	19	C	C	C	C	C	VC	VC	C	C	M	L	M	M	M	M	M	L	M	L	L	L	L	L	L	L	L	L
	31	C	C	C	C	C	VC	VC	C	C	M	L	M	M	M	M	M	L	M	L	L	L	L	L	L	L	L	L
	32	C	C	C	C	C	VC	VC	C	C	M	L	M	M	M	M	M	L	M	L	L	L	L	L	L	L	L	L
	33	C	C	C	C	C	VC	VC	C	C	M	L	M	M	M	M	M	L	M	L	L	L	L	L	L	L	L	T
	34	C	C	C	C	C	VC	VC	C	C	M	L	M	M	M	M	M	L	M	L	L	L	L	L	L	L	L	T
	35	C	C	C	C	C	VC	VC	C	C	M	L	M	M	M	M	M	L	M	L	L	L	L	L	L	L	L	T
	36	C	C	C	C	C	VC	VC	C	C	M	L	M	M	M	M	M	L	M	L	L	L	L	L	L	L	L	T
	8	VC	C	VC	VC	VC	VC	VC	C	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
	9	VC	C	VC	VC	VC	VC	VC	C	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
	10	VC	C	VC	VC	VC	VC	VC	C	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
	29	VC	C	VC	VC	VC	VC	VC	C	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
	30	VC	C	VC	VC	VC	VC	VC	C	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
	31	VC	C	VC	VC	VC	VC	VC	C	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
	47	VC	C	VC	VC	VC	VC	VC	C	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
	48	VC	C	VC	VC	VC	VC	VC	C	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
	49	VC	C	VC	VC	VC	VC	VC	C	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
	54	VC	C	VC	VC	VC	VC	VC	C	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
	55	VC	C	VC	VC	VC	VC	VC	C	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
	56	VC	C	VC	VC	VC	VC	VC	C	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
	57	VC	C	VC	VC	VC	VC	VC	C	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
	58	VC	C	VC	VC	VC	VC	VC	C	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
	17	S	C	S	S	S	C	S	S	S	D	D	D	D	D	D	D	D	D	T	TL	T	T	T	L	T	L	T
	18	S	S	S	S	S	C	S	S	S	D	D	D	D	D	D	D	D	D	T	TL	T	T	T	L	T	L	T
	31	S	S	S	S	S	C	S	S	S	D	D	D	D	D	D	D	D	D	T	TL	T	T	T	L	T	L	T
	32	S	S	S	S	S	C	S	S	S	D	D	D	D	D	D	D	D	D	T	TL	T	T	T	L	T	L	T
	33	S	S	S	S	S	C	S	S	S	D	D	D	D	D	D	D	D	D	T	TL	T	T	T	L	T	L	T
	34	S	S	S	S	S	C	S	S	S	D	D	D	D	D	D	D	D	D	T	TL	T	T	T	L	T	L	T
	35	S	S	S	S	S	C	S	S	S	D	D	D	D	D	D	D	D	D	T	TL	T	T	T	L	T	L	T
	36	S	S	S	S	S	C	S	S	S	D	D	D	D	D	D	D	D	D	T	TL	T	T	T	L	T	L	T
	23	S	S	S	S	S	C	VS	S	M	D	D	D	D	D	D	D	M	D	T	T	T	T	T	L	T	L	T
	24	S	S	S	S	S	C	VS	S	M	D	D	D	D	D	D	D	M	D	T	T	T	T	T	L	T	L	T
	25	S	S	S	S	S	C	VS	S	M	D	D	D	D	D	D	D	M	D	T	T	T	T	T	L	T	L	T
	26	S	S	S	S	S	C	VS	S	M	D	D	D	D	D	D	D	M	D	T	T	T	T	T	L	T	L	T
	43	S	S	S	S	S	C	VS	S	M	D	D	D	D	D	D	D	M	D	T	T	T	T	T	L	T	L	T
	44	S	S	S	S	S	C	VS	S	M	D	D	D	D	D	D	D	M	D	T	T	T	T	T	L	T	L	T
	45	S	S	S	S	S	C	VS	S	M	D	D	D	D	D	D	D	M	D	T	T	T	T	T	L	T	L	T
	46	S	S	S	S	S	C	VS	S	M	D	D	D	D	D	D	D	M	D	T	T	T	T	T	L	T	L	T
	47	S	S	S	S	S	C	VS	S	M	D	D	D	D	D	D	D	M	D	T	T	T	T	T	L	T	L	T
	48	S	S	S	S	S	C	VS	S	M	D	D	D	D	D	D	D	M	D	T	T	T	T	T	L	T	L	T
	49	S	S	S	S	S	C	VS	S	M	D	D	D	D	D	D	D	M	D	T	T	T	T	T	L	T	L	T
II	24	VS	VS	VS	S	S	M	VS	S	VS	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	25	VS	VS	VS	S	S	M	VS	S	VS	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	27	VS	VS	VS	S	S	M	VS	S	VS	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	28	VS	VS	VS	S	S	M	VS	S	VS	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	29	VS	VS	VS	S	S	M	VS	S	VS	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T

ROW No. 4

Mark	Sheet No.	Texture: Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc. Adam 6	Mc. Donnell 7	Smith 8	Wheaton 9	Color: Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc. Adam 6	Mc. Donnell 7	Smith 8	Wheaton 9	Adherence: Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc. Adam 6	Mc. Donnell 7	Smith 8	Wheaton 9
II*	48	VS	VS	S	S	VS	C	VS	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
	49	VS	VS	S	S	VS	C	VS	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
	50	VS	VS	S	S	VS	C	VS	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
	51	VS	VS	S	S	VS	C	VS	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
	52	VS	VS	S	S	VS	C	VS	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
	53	VS	VS	S	S	VS	C	VS	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
	54	VS	VS	S	S	VS	C	VS	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
	55	VS	VS	S	S	VS	C	VS	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
	56	VS	VS	S	S	VS	C	VS	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
KK	28	S	VS	S	S	S	C	VS	S	M	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	29	S	VS	S	S	S	C	VS	S	M	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	30	S	VS	S	S	S	C	VS	S	M	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	31	S	VS	S	S	S	C	VS	S	M	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	32	S	VS	S	S	S	C	VS	S	M	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	33	S	VS	S	S	S	C	VS	S	M	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	34	S	VS	S	S	S	C	VS	S	M	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
KK*	51	S	VS	S	S	S	C	VS	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	52	S	VS	S	S	S	C	VS	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	53	S	VS	S	S	S	C	VS	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	54	S	VS	S	S	S	C	VS	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	55	S	VS	S	S	S	C	VS	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	56	S	VS	S	S	S	C	VS	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	57	S	VS	S	S	S	C	VS	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	58	S	VS	S	S	S	C	VS	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
MM†	33	C	M	M	C	C	VC	C	M	C	L	D	M	L	D	M	M	M	M	L	L	L	L	L	L	L	L	L
	34	C	M	M	C	C	VC	C	M	C	L	D	M	L	D	M	M	M	M	L	L	L	L	L	L	L	L	L
	35	C	M	M	C	C	VC	C	M	C	L	D	M	L	D	M	M	M	M	L	L	L	L	L	L	L	L	L
	36	C	M	M	C	C	VC	C	M	C	L	D	M	L	D	M	M	M	M	L	L	L	L	L	L	L	L	L
	37	C	M	M	C	C	VC	C	M	C	L	D	M	L	D	M	M	M	M	L	L	L	L	L	L	L	L	L
	38	C	M	M	C	C	VC	C	M	C	L	D	M	L	D	M	M	M	M	L	L	L	L	L	L	L	L	L
	39	C	M	M	C	C	VC	C	M	C	L	D	M	L	D	M	M	M	M	L	L	L	L	L	L	L	L	L
	40	C	M	M	C	C	VC	C	M	C	L	D	M	L	D	M	M	M	M	L	L	L	L	L	L	L	L	L
	41	C	M	M	C	C	VC	C	M	C	L	D	M	L	D	M	M	M	M	L	L	L	L	L	L	L	L	L
	42	C	M	M	C	C	VC	C	M	C	L	D	M	L	D	M	M	M	M	L	L	L	L	L	L	L	L	L
SS	33	–	VC	VC	VC	VC	VC	VC	VC	VC	–	L	L	L	L	M	L	L	M	–	L	L	L	L	L	L	L	L
	34	VC	VC	VC	VC	VC	VC	VC	VC	VC	L	L	L	L	L	M	L	L	M	L	L	L	L	L	L	L	L	L
	35	–	VC	VC	VC	VC	VC	VC	VC	VC	–	L	L	L	L	M	L	L	M	–	L	L	L	L	L	L	L	L
	36	VC	VC	VC	VC	VC	VC	VC	VC	VC	L	L	L	L	L	M	L	L	M	L	L	L	L	L	L	L	L	L
	37	VC	VC	VC	VC	VC	VC	VC	VC	VC	L	L	L	L	L	M	L	L	M	L	L	L	L	L	L	L	L	L
	38	VC	VC	VC	VC	VC	VC	VC	VC	VC	L	L	L	L	L	M	L	L	M	L	L	L	L	L	L	L	L	L
	39	–	VC	VC	VC	VC	VC	VC	VC	VC	–	L	L	L	L	M	L	L	M	–	L	L	L	L	L	L	L	L
	40	–	VC	VC	VC	VC	VC	VC	VC	VC	–	L	L	L	L	M	L	L	M	–	L	L	L	L	L	L	L	L
	41	VC	VC	VC	VC	VC	VC	VC	VC	VC	L	L	L	L	L	M	L	L	M	L	L	L	L	L	L	L	L	L
	42	VC	VC	VC	VC	VC	VC	VC	VC	VC	L	L	L	L	L	M	L	L	M	L	L	L	L	L	L	L	L	L
TT	33	M	S	S	M	S	C	S	S	M	D	D	M	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	34	M	S	S	M	S	C	S	S	M	D	D	M	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	35	M	S	S	M	S	C	S	S	M	D	D	M	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	36	M	S	S	M	S	C	S	S	M	D	D	M	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	37	M	S	S	M	S	C	S	S	M	D	D	M	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	38	M	S	S	M	S	C	S	S	M	D	D	M	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	39	M	S	S	M	S	C	S	S	M	D	D	M	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	40	M	S	S	M	S	C	S	S	M	D	D	M	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	41	M	S	S	M	S	C	S	S	M	D	D	M	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	42	M	S	S	M	S	C	S	S	M	D	D	M	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
UU	33	M	S	M	M	S	C	S	S	M	D	D	D	M	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	34	M	S	M	M	S	C	S	S	M	D	D	D	M	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	35	M	S	M	M	S	C	S	S	M	D	D	D	M	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	36	M	S	M	M	S	C	S	S	M	D	D	D	M	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	37	M	S	M	M	S	C	S	S	M	D	D	D	M	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	38	M	S	M	M	S	C	S	S	M	D	D	D	M	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	39	M	S	M	M	S	C	S	S	M	D	D	D	M	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	40	M	S	M	M	S	C	S	S	M	D	D	D	M	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	41	M	S	M	M	S	C	S	S	M	D	D	D	M	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	42	M	S	M	M	S	C	S	S	M	D	D	D	M	D	D	D	D	D	T	T	T	T	T	L	T	L	T
VV	43	M	S	M	M	M	C	S	S	M	D	D	D	M	D	D	D	M	D	T	T	T	T	T	L	T	L	T
	44	M	S	M	M	M	C	S	S	M	D	D	D	M	D	D	D	M	D	T	T	T	T	T	L	T	L	T
	45	M	S	M	M	M	C	S	S	M	D	D	D	M	D	D	D	M	D	T	T	T	T	T	L	T	L	T
	46	M	S	M	M	M	C	S	S	M	D	D	D	M	D	D	D	M	D	T	T	T	T	T	L	T	L	T
	47	M	S	M	M	M	C	S	S	M	D	D	D	M	D	D	D	M	D	T	T	T	T	T	L	T	L	T
	48	M	S	M	M	M	C	S	S	M	D	D	D	M	D	D	D	M	D	T	T	T	T	T	L	T	L	T
	49	M	S	M	M	M	C	S	S	M	D	D	D	M	D	D	D	M	D	T	T	T	T	T	L	T	L	T
	50	M	S	M	M	M	C	S	S	M	D	D	D	M	D	D	D	M	D	T	T	T	T	T	L	T	L	T
	51	M	S	M	M	M	C	S	S	M	D	D	D	M	D	D	D	M	D	T	T	T	T	T	L	T	L	T

ROW No. 5

Mark	Sheet No.	Texture: Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc. Adam 6	Mc. Donnell 7	Smith 8	Wheaton 9	Color: Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc. Adam 6	Mc. Donnell 7	Smith 8	Wheaton 9	Adherence: Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc. Adam 6	Mc. Donnell 7	Smith 8	Wheaton 9
XX	33	VC	VC	VC	VC	VC	VC	VC	C	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
	34	VC	VC	VC	VC	VC	VC	VC	C	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
	35	VC	VC	VC	VC	VC	VC	VC	C	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
	36	VC	VC	VC	VC	VC	VC	VC	C	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
	37	VC	VC	VC	VC	VC	VC	VC	C	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
	38	VC	VC	VC	VC	VC	VC	VC	C	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
	39	VC	VC	VC	VC	VC	VC	VC	C	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
	40	VC	VC	VC	VC	VC	VC	VC	C	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
	41	–	VC	VC	VC	VC	VC	VC	C	VC	–	L	L	L	M	M	L	L	M	–	L	L	L	L	L	L	L	L
	42	–	VC	VC	VC	VC	VC	VC	C	VC	–	L	L	L	M	M	L	L	M	–	L	L	L	L	L	L	L	L
ZZ	208	VS	VS	VS	M	VS	M	VS	S	VS	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
	209	VS	VS	VS	M	VS	M	VS	S	VS	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
	213	VS	VS	VS	M	VS	M	VS	S	VS	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
	314	VS	VS	VS	M	VS	M	VS	S	VS	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
	426	C	C	VC	C	C	VC	C	C	C	L	M	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
	427	C	C	VC	C	C	VC	C	C	C	L	M	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
	507	M	VS	VS	M	VS	C	S	M	M	D	D	D	D	D	D	D	M	D	T	T	T	T	T	L	T	L	T
	510	M	VS	VS	M	VS	C	S	M	S	D	D	D	D	D	D	D	M	D	T	T	T	T	T	L	T	L	T
	509	M	VS	VS	M	VS	C	S	M	S	D	D	D	D	D	D	D	M	D	T	T	T	T	T	L	T	L	T
	612	VS	VS	VS	S	VS	M	VS	S	VS	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
	614	VS	VS	VS	S	VS	M	VS	S	VS	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
	615	VS	VS	VS	S	VS	M	VS	S	VS	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
	714	VS	VS	VS	S	VS	M	S	S	VS	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	715	VS	VS	VS	S	VS	M	S	S	VS	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
OO	29	C	C	VC	VC	C	VC	VC	C	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
	30	C	C	VC	VC	C	VC	VC	C	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
	31	C	C	VC	VC	C	VC	VC	C	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
	32	C	C	VC	VC	C	VC	VC	C	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
	33	C	C	VC	VC	C	VC	VC	C	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
	34	C	C	VC	VC	C	VC	VC	C	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
	35	C	C	VC	VC	C	VC	VC	C	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
	36	C	C	VC	VC	C	VC	VC	C	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
CCC	5	M	M	M	C	M	C	M	M	M	M	D	M	M	D	D	D	M	D	T	L	TL	L	T	L	L	L	T
	6	M	M	M	C	M	C	M	M	M	M	D	M	M	D	D	D	M	D	T	L	TL	L	T	L	L	L	T
	7	M	M	M	C	M	C	M	M	M	M	D	M	M	D	D	D	M	D	T	L	TL	L	T	L	L	L	T
	8	M	M	M	C	M	C	M	M	M	M	D	M	M	D	D	D	M	D	T	L	TL	L	T	L	L	L	T
	9	M	M	M	C	M	C	M	M	M	M	D	M	M	D	D	D	M	D	T	L	TL	L	T	L	L	L	T
	10	M	M	M	C	M	C	M	M	M	M	D	M	M	D	D	D	M	D	T	L	TL	L	T	L	L	L	T
	11	M	M	M	C	M	C	M	M	M	M	D	M	M	D	D	D	M	D	T	L	TL	L	T	L	L	L	T
	12	M	M	M	C	M	C	M	M	M	M	D	M	M	D	D	D	M	D	T	L	TL	L	T	L	L	L	T
A	35	–	–	–	VC	–	–	–	–	VC	–	–	–	L	–	–	–	–	M	–	–	–	L	–	–	–	–	L
	36	–	–	–	VC	–	–	–	–	VC	–	–	–	L	–	–	–	–	M	–	–	–	L	–	–	–	–	L
	37	–	–	–	VC	–	–	–	–	VC	–	–	–	L	–	–	–	–	M	–	–	–	L	–	–	–	–	L
	38	–	–	–	VC	–	–	–	–	VC	–	–	–	L	–	–	–	–	M	–	–	–	L	–	–	–	–	L
	39	–	–	–	VC	–	–	–	–	VC	–	–	–	L	–	–	–	–	M	–	–	–	L	–	–	–	–	L
	40	–	–	–	VC	–	–	–	–	VC	–	–	–	L	–	–	–	–	M	–	–	–	L	–	–	–	–	L
	41	–	–	–	VC	–	–	–	–	VC	–	–	–	L	–	–	–	–	M	–	–	–	L	–	–	–	–	L
	42	–	–	–	VC	–	–	–	–	VC	–	–	–	L	–	–	–	–	M	–	–	–	L	–	–	–	–	L
	43	–	–	–	VC	–	–	–	–	VC	–	–	–	L	–	–	–	–	M	–	–	–	L	–	–	–	–	L
	44	–	–	–	VC	–	–	–	–	VC	–	–	–	L	–	–	–	–	M	–	–	–	L	–	–	–	–	L
	45	–	–	–	VC	–	–	–	–	VC	–	–	–	L	–	–	–	–	M	–	–	–	L	–	–	–	–	L
	46	–	–	–	VC	–	–	–	–	VC	–	–	–	L	–	–	–	–	M	–	–	–	L	–	–	–	–	L
	47	–	–	–	VC	–	–	–	–	VC	–	–	–	L	–	–	–	–	M	–	–	–	L	–	–	–	–	L
B	21	M	M	M	C	M	C	M	M	M	M	D	M	L	D	M	M	M	D	T	T	L	L	T	L	L	L	L
	22	M	M	M	C	M	C	M	M	M	M	D	M	L	D	M	M	M	D	T	T	L	L	T	L	L	L	L
	23	M	M	M	C	M	C	M	M	M	M	D	M	L	D	M	M	M	D	T	T	L	L	T	L	L	L	L
	34	S	M	S	M	M	M	S	M	S	D	D	M	M	D	D	D	M	D	T	T	T	T	T	L	T	L	T
	35	–	C	M	C	M	VC	C	C	C	–	M	L	M	D	M	M	M	M	–	L	L	L	T	L	L	L	L
	36	–	C	M	C	M	VC	C	C	C	–	M	L	M	D	M	M	M	M	–	L	L	L	T	L	L	L	L
	37	–	C	M	C	M	VC	C	C	C	–	M	L	M	D	M	M	M	M	–	L	L	L	T	L	L	L	L
	38	–	C	M	C	M	VC	C	C	C	–	M	L	M	D	M	M	M	M	–	L	L	L	T	L	L	L	L
	39	–	M	S	M	M	C	M	S	S	–	D	M	D	D	D	D	D	D	–	T	T	T	T	L	L	L	T
C	20	–	M	C	C	M	VC	M	M	M	–	M	M	M	D	M	M	M	D	–	L	L	L	T	L	L	L	T
	21	–	M	C	C	M	VC	M	M	M	–	M	M	M	D	M	M	M	D	–	L	L	L	T	L	L	L	T
	22	–	M	C	C	M	VC	M	M	M	–	M	M	M	D	M	M	M	D	–	L	L	L	T	L	L	L	T
	32	–	M	C	C	M	VC	M	M	M	–	M	M	M	D	M	M	M	D	–	L	L	L	T	L	L	L	T
	33	C	M	C	C	M	VC	M	M	M	M	M	M	M	D	M	M	M	D	L	L	L	L	T	L	L	L	T
	34	–	M	C	C	M	VC	M	M	M	–	M	M	M	D	M	M	M	D	–	L	L	L	T	L	L	L	T
	35	–	M	C	C	M	VC	M	M	M	–	M	M	M	D	M	M	M	D	–	L	L	L	T	L	L	L	T

ROW No. 6

Mark	Sheet No.	Texture: Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc. Adam 6	Mc. Donnell 7	Smith 8	Wheaton 9	Color: Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc. Adam 6	Mc. Donnell 7	Smith 8	Wheaton 9	Adherence: Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc. Adam 6	Mc. Donnell 7	Smith 8	Wheaton 9
D	35	–	–	–	VC	–	VC	–	VC	VC	–	–	–	L	–	M	–	L	M	–	–	–	L	–	L	–	L	L
	36	–	–	–	VC	–	VC	–	VC	VC	–	–	–	L	–	M	–	L	M	–	–	–	L	–	L	–	L	L
	38	–	–	–	VC	–	VC	–	VC	VC	–	–	–	L	–	M	–	L	M	–	–	–	L	–	L	–	L	L
	39	–	–	–	VC	–	VC	–	VC	VC	–	–	–	L	–	M	–	L	M	–	–	–	L	–	L	–	L	L
	40	–	–	–	VC	–	VC	–	VC	VC	–	–	–	L	–	M	–	L	M	–	–	–	L	–	L	–	L	L
E	29	–	–	–	M	M	C	–	S	M	–	–	–	D	D	D	–	D	D	–	–	–	T	T	L	–	L	T
	30	–	–	–	M	M	C	–	S	M	–	–	–	D	D	D	–	D	D	–	–	–	T	T	L	–	L	T
	31	–	–	–	M	M	C	–	S	M	–	–	–	D	D	D	–	D	D	–	–	–	T	T	L	–	L	T
	32	–	–	–	M	M	C	–	S	M	–	–	–	D	D	D	–	D	D	–	–	–	T	T	L	–	L	T
	33	–	–	–	M	M	C	–	S	M	–	–	–	D	D	D	–	D	D	–	–	–	T	T	L	–	L	T
	34	–	–	–	M	M	C	–	S	M	–	–	–	D	D	D	–	D	D	–	–	–	T	T	L	–	L	T
	35	–	–	–	M	M	C	–	S	M	–	–	–	D	D	D	–	D	D	–	–	–	T	T	L	–	L	T
	36	–	–	–	M	M	C	–	S	M	–	–	–	D	D	D	–	D	D	–	–	–	T	T	L	–	L	T
H	43	S	S	S	S	S	C	S	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	45	S	S	S	S	S	C	S	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	47	S	S	S	S	S	C	S	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	49	S	S	S	S	S	C	S	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	50	S	S	S	S	S	C	S	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	53	S	S	S	S	S	C	S	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	54	S	S	S	S	S	C	S	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	55	S	S	S	S	S	C	S	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
I	42	S	VS	S	S	S	C	VS	VS	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
	43	S	VS	S	S	S	C	VS	VS	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
	44	S	VS	S	S	S	C	VS	VS	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
	45	S	VS	S	S	S	C	VS	VS	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
	46	S	VS	S	S	S	C	VS	VS	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
	47	S	VS	S	S	S	C	VS	VS	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
	48	S	VS	S	S	S	C	VS	VS	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
	49	S	VS	S	S	S	C	VS	VS	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
	50	S	VS	S	S	S	C	VS	VS	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
	51	S	VS	S	S	S	C	VS	VS	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
	52	S	VS	S	S	S	C	VS	VS	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
	53	S	VS	S	S	S	C	VS	VS	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
	54	S	VS	S	S	S	C	VS	VS	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
	55	S	VS	S	S	S	C	VS	VS	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
K	37	S	VS	S	S	S	C	VS	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	38	S	VS	S	S	S	C	VS	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	39	S	VS	S	S	S	C	VS	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	40	S	VS	S	S	S	C	VS	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	41	S	VS	S	S	S	C	VS	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	42	S	VS	S	S	S	C	VS	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	43	S	VS	S	S	S	C	VS	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	44	S	VS	S	S	S	C	VS	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	45	S	VS	S	S	S	C	VS	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	46	S	VS	S	S	S	C	VS	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	47	S	VS	S	S	S	C	VS	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	48	S	VS	S	S	S	C	VS	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
M	33	M	M	M	C	M	C	S	M	M	D	D	M	M	D	D	D	M	D	L	TL	TL	L	T	L	L	L	T
	34	M	M	M	C	M	C	S	M	M	D	D	M	M	D	D	D	M	D	L	TL	TL	L	T	L	L	L	T
	35	M	M	M	C	M	C	S	M	M	D	D	M	M	D	D	D	M	D	L	TL	TL	L	T	L	L	L	T
	36	–	M	M	C	M	C	S	M	M	–	D	M	M	D	D	D	M	D	–	TL	TL	L	T	L	L	L	T
	37	M	M	M	C	M	C	S	M	M	D	D	M	M	D	D	D	M	D	L	TL	TL	L	T	L	L	L	T
	38	M	M	M	C	M	C	S	M	M	D	D	M	M	D	D	D	M	D	L	TL	TL	L	T	L	L	L	T
	39	M	M	M	C	M	C	S	M	M	D	D	M	M	D	D	D	M	D	L	TL	TL	L	T	L	L	L	T
	40	M	M	M	C	M	C	S	M	M	D	D	M	M	D	D	D	M	D	L	TL	TL	L	T	L	L	L	T
	41	M	M	M	C	M	C	S	M	M	D	D	M	M	D	D	D	M	D	L	TL	TL	L	T	L	L	L	T
	42	–	M	M	C	M	C	S	M	M	–	D	M	M	D	D	D	M	D	–	TL	TL	L	T	L	L	L	T
S	33	–	–	–	VC	–	VC	–	–	VC	–	–	–	L	–	M	–	–	M	–	–	–	L	–	L	–	–	L
	34	–	–	–	VC	–	VC	–	–	VC	–	–	–	L	–	M	–	–	M	–	–	–	L	–	L	–	–	L
	35	–	–	–	VC	–	VC	–	–	VC	–	–	–	L	–	M	–	–	M	–	–	–	L	–	L	–	–	L
	36	–	–	–	VC	–	VC	–	–	VC	–	–	–	L	–	M	–	–	M	–	–	–	L	–	L	–	–	L
	37	–	–	–	VC	–	VC	–	–	VC	–	–	–	L	–	M	–	–	M	–	–	–	L	–	L	–	–	L
	38	–	–	–	VC	–	VC	–	–	VC	–	–	–	L	–	M	–	–	M	–	–	–	L	–	L	–	–	L
	39	–	–	–	VC	–	VC	–	–	VC	–	–	–	L	–	M	–	–	M	–	–	–	L	–	L	–	–	L
	40	–	–	–	VC	–	VC	–	–	VC	–	–	–	L	–	M	–	–	M	–	–	–	L	–	L	–	–	L
	41	–	–	–	VC	–	VC	–	–	VC	–	–	–	L	–	M	–	–	M	–	–	–	L	–	L	–	–	L
	42	–	–	–	VC	–	VC	–	–	VC	–	–	–	L	–	M	–	–	M	–	–	–	L	–	L	–	–	L

ROW No. 7

Mark	Sheet No.	Texture: Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc. Adam 6	Mc. Donnell 7	Smith 8	Wheaton 9	Color: Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc. Adam 6	Mc. Donnell 7	Smith 8	Wheaton 9	Adherence: Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc. Adam 6	Mc. Donnell 7	Smith 8	Wheaton 9
T	33	–	S	S	M	S	C	S	M	S	–	D	D	D	D	D	D	D	D	–	T	TL	T	T	L	T	L	T
	34	M	S	S	M	S	C	S	M	S	D	D	D	D	D	D	D	D	D	T	T	TL	T	T	L	T	L	T
	35	–	S	S	M	S	C	S	M	S	–	D	D	D	D	D	D	D	D	–	T	TL	T	T	L	T	L	T
	36	–	S	S	M	S	C	S	M	S	–	D	D	D	D	D	D	D	D	–	T	TL	T	T	L	T	L	T
	37	–	S	S	M	S	C	S	M	S	–	D	D	D	D	D	D	D	D	–	T	TL	T	T	L	T	L	T
	38	–	S	S	M	S	C	S	M	S	–	D	D	D	D	D	D	D	D	–	T	TL	T	T	L	T	L	T
	39	–	S	S	M	S	C	S	M	S	–	D	D	D	D	D	D	D	D	–	T	TL	T	T	L	T	L	T
	40	M	S	S	M	S	C	S	M	S	D	D	D	D	D	D	D	D	D	T	T	TL	T	T	L	T	L	T
	41	M	S	S	M	S	C	S	M	S	D	D	D	D	D	D	D	D	D	T	T	TL	T	T	L	T	L	T
	42	M	S	S	M	S	C	S	M	S	D	D	D	D	D	D	D	D	D	T	T	TL	T	T	L	T	L	T
U	33	M	S	M	M	S	C	M	M	M	D	D	D	D	D	D	D	M	D	T	TL	TL	T	T	L	T	L	T
	34	M	S	M	M	S	C	M	M	M	D	D	D	D	D	D	D	M	D	T	TL	TL	T	T	L	T	L	T
	35	M	S	M	M	S	C	M	M	M	D	D	D	D	D	D	D	M	D	T	TL	TL	T	T	L	T	L	T
	36	M	S	M	M	S	C	M	M	M	D	D	D	D	D	D	D	M	D	T	TL	TL	T	T	L	T	L	T
	37	M	S	M	M	S	C	M	M	M	D	D	D	D	D	D	D	M	D	T	TL	TL	T	T	L	T	L	T
	38	M	S	M	M	S	C	M	M	M	D	D	D	D	D	D	D	M	D	T	TL	TL	T	T	L	T	L	T
	39	M	S	M	M	S	C	M	M	M	D	D	D	D	D	D	D	M	D	T	TL	TL	T	T	L	T	L	T
	40	–	S	M	M	S	C	M	M	M	–	D	D	D	D	D	D	M	D	–	TL	TL	T	T	L	T	L	T
	41	–	S	M	M	M	C	M	M	M	–	D	D	D	D	D	D	M	D	–	TL	TL	T	T	L	T	L	T
	42	M	S	M	M	M	C	M	M	M	D	D	D	D	D	D	D	M	D	T	TL	TL	T	T	L	T	L	T
V	33	M	M	S	M	M	C	M	M	M	D	D	D	D	D	D	D	M	D	T	TL	T	T	T	L	T	L	T
	34	M	M	S	M	M	C	M	M	M	D	D	D	D	D	D	D	M	D	T	TL	T	T	T	L	T	L	T
	35	M	M	S	M	M	C	M	M	M	D	D	D	D	D	D	D	M	D	T	TL	T	T	T	L	T	L	T
	36	–	M	S	M	M	C	M	M	M	–	D	D	D	D	D	D	M	D	–	TL	T	T	T	L	T	L	T
	37	–	M	S	M	M	C	M	M	M	–	D	D	D	D	D	D	M	D	–	TL	T	T	T	L	T	L	T
	38	M	M	S	M	M	C	M	M	M	D	D	D	D	D	D	D	M	D	T	TL	T	T	T	L	T	L	T
	39	–	M	S	M	M	C	M	M	M	–	D	D	D	D	D	D	M	D	–	TL	T	T	T	L	T	L	T
	40	M	M	S	M	M	C	M	M	M	D	D	D	D	D	D	D	M	D	T	TL	T	T	T	L	T	L	T
	41	M	M	S	M	M	C	M	M	M	D	D	D	D	D	D	D	M	D	T	TL	T	T	T	L	T	L	T
	42	–	M	S	M	M	C	M	M	M	–	D	D	D	D	D	D	M	D	–	TL	T	T	T	L	T	L	T
X	33	–	–	–	VC	–	VC	–	–	VC	–	–	–	L	–	M	–	–	M	–	–	–	L	–	L	–	L	L
	34	–	–	–	VC	–	VC	–	–	VC	–	–	–	L	–	M	–	–	M	–	–	–	L	–	L	–	L	L
	35	–	–	–	VC	–	VC	–	–	VC	–	–	–	L	–	M	–	–	M	–	–	–	L	–	L	–	–	L
	36	–	–	–	VC	–	VC	–	–	VC	–	–	–	L	–	M	–	–	M	–	–	–	L	–	L	–	–	L
	37	–	–	–	VC	–	VC	–	–	VC	–	–	–	L	–	M	–	–	M	–	–	–	L	–	L	–	–	L
	38	–	–	–	VC	–	VC	–	–	VC	–	–	–	L	–	M	–	–	M	–	–	–	L	–	L	–	–	L
	39	–	–	–	VC	–	VC	–	–	VC	–	–	–	L	–	M	–	–	M	–	–	–	L	–	L	–	–	L
	40	–	–	–	VC	–	VC	–	–	VC	–	–	–	L	–	M	–	–	M	–	–	–	L	–	L	–	–	L
	41	–	–	–	VC	–	VC	–	–	VC	–	–	–	L	–	M	–	–	M	–	–	–	L	–	L	–	–	L
	42	–	–	–	VC	–	VC	–	–	VC	–	–	–	L	–	M	–	–	M	–	–	–	L	–	L	–	–	L
Z	314	VS	VS	VS	VS	S	M	VS	VS	VS	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
	422	VC	–	–	VC	S	VC	–	–	C	L	–	–	L	D	M	–	–	M	L	–	–	L	T	L	–	–	L
	423	VC	–	–	VC	S	VC	–	–	C	L	–	–	L	D	M	–	–	M	L	–	–	L	T	L	–	–	L
	424	VC	–	–	VC	S	VC	–	–	C	L	–	–	L	D	M	–	–	M	L	–	–	L	T	L	–	–	L
	509	S	S	S	S	M	C	S	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	513	S	S	VS	S	M	C	S	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	516	S	S	VS	S	M	C	S	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	607	S	VS	VS	S	M	M	S	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	608	S	VS	VS	S	M	M	S	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	609	S	VS	VS	S	M	M	S	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	712	VS	VS	VS	S	M	M	S	VS	VS	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	714	VS	VS	VS	S	M	M	S	VS	VS	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	715	VS	VS	VS	S	M	M	S	VS	VS	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
O	29	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	30	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	31	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	32	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	33	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	34	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	35	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	36	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Y*	7	–	–	–	VC	C	VC	–	C	C	–	–	–	L	M	M	–	M	M	–	–	–	L	L	L	–	L	T
	8	–	–	–	VC	C	VC	–	C	C	–	–	–	L	M	M	–	M	M	–	–	–	L	L	L	–	L	T
	9	–	–	–	VC	C	VC	–	C	C	–	–	–	L	M	M	–	M	M	–	–	–	L	L	L	–	L	T
YY*	7	VC	VC	VC	VC	C	VC	VC	VC	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
	8	VC	VC	VC	VC	C	VC	VC	VC	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
	9	VC	VC	VC	VC	C	VC	VC	VC	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L

* Sand Blasted.

† Open Annealed.

* Exposed 6-5-17.

— J. A. AUPPERLE —

3,24 Failure.
1,32- ,,
14- ,,
3,34 ,,
,,
4 ,,
3,34 ,,
7,28 ,,
,,
31,32 ,,
,,
0- ,,
,,
,31,32 ,,

O-25, 26, 27, 28-Failure.
Z-6, 7, 11, ,,
AA* 50, 51, 52, 53, 54, 55, 56 Failure.
AA-25, 26, 27, 28, 29, 30- ,,
XX-29, 30, 31, 32, 41 ,,
SS-33, 35, 39, 40 ,,
A-35 to 47 incl. ,,
B-35, 36, 37, 38- ,,
C-20, 21, 22, 32, 34, 35 ,,
D-35, 36, 38, 39, 40 ,,
E-29 to 36 incl. ,,
M-36, 42 ,,
S-33 to 42 incl. ,,
T-33, 35 to 39 incl. ,,

Y-7, 8, 9 Failure.
X-33 to 42 incl. ,,
U-40, 41- ,,
V-36, 37, 39, 42 ,,
Z-422, 423, 424 ,,
O-29 to 36 incl. ,,

— D. M. BUCK —

AA-21, 22, 23, 24-Failure.
SS-29, 30, 31, 32 ,,
XX-29, 30, 31, 32 ,,
ZZ-8, 10, 14 ,,
A-31, 32, 33, 34 ,,
B-17, 18 ,,
C-11, 13, 14 ,,
D-30, 31, 33, 34 ,,
E-25, 26, 27, 28 ,,
M-32 ,,
S-29, 30, 31, 32 ,,
T-32- ,,
U-29, 30 ,,
V-29 ,,

X-29, 30, 31, 32—Failure.
O-25, 26, 27, 28 ,,
Z-6, 7, 11- ,,
AA-25 to 30 incl. ,,
AA*-50 to 56 ,, ,,
SS-33, 35, 39, 40 ,,
XX-41, ,,
A-35 to 47 incl. ,,
B-35, 36, 37, 38 ,,
C-20, 21, 22, 32, 34, 35 ,,
D-35, 36, 38, 39, 40 ,,
E-29 to 36 incl. ,,
M-36, 42 ,,
S-33 to 42 incl. ,,

T-33, 35 to 39 incl.-Failure.
U-40, 41- ,,
V-36, 37, 39, 42 ,,
X-33 to 42 incl. ,,
Z-422, 423, 424 ,,
O-29 to 36 incl. ,,
Y* 7, 8, 9 ,,

— W. A. COOPER —

AA-21 to 24 incl. Failure.
SS-29 ,, 32 ,, ,,
XX-29 ,, 32 ,, ,,
ZZ-8, 10, 14 ,,
A-31 to 34 incl. ,,
B-17, 18-Failure, Holes.
C-11, 13, 14 ,, ,,
D-30 to 34 incl. Failure.
E-25 ,, 28 ,, ,,
M-32- ,,
S-29 to 32 incl. ,,
T-32- ,,
U-29, 30 ,,
V-29 ,,

X-29 to 32 incl. Failure.
O-25 to 28 ,, ,,
Z-6, 7, 11 ,,
AA-25 to 30 incl. ,,
AA* 50 ,, 56 ,, ,,
SS-33, 35, 39, 40 ,,
XX-41- ,,
A-35 to 47- ,,
B-35 ,, 38 incl. ,,
C-20 to 22, 32, 34, 35 ,,
D-35, 36, 38, 39, 40 ,,
E-29 to 36 incl. ,,
I-50-Bullet Hole. ,,
M-36, 42 ,,

S-33 to 42 incl. Failure.
T-33, 35 to 39 ,, ,,
U-40, 41 ,,
V-36, 37, 39, 42- ,,
V-40-Bullet Hole ,,
X-33 to 42 incl. ,,
Z-422, 423, 424 ,,
O-29 to 36 incl. ,,
Y* 7, 8, 9 ,,

— W. R. FLEMING —

AA-21, 22, 23, 24 Failure.
SS-31, 32 ,,
ZZ-8, 10, 14 ,,
A-31, 32, 33, 34 ,,
B-17, 18 ,,
C-11, 13, 14 ,,
D-30, 31, 33, 34 ,,
E-25, 26, 27, 28 ,,
M-32 ,,
S-29, 30, 31, 32 ,,
T-32 ,,
U-29, 30 ,,
Y-29 ,,
X-29, 30, 31, 32 ,,

O-25, 26, 27, 28 Failure.
Z-6, 7, 11 ,,
AA-25, 26, 27, 28, 29, 30 ,,
AA* 50 to 56 incl. ,,
SS-33, 35, 39, 40 ,,
XX-41 ,,
A-35 to 47 incl. ,,
B-35 to 38 ,, . ,,
C-20 to 22, 32, 34, 35 ,,
D-35, 36, 38, 39, 40 ,,
E-29 to 36 incl. ,,
I-50-Rifle Hole. ,,
M-36-Failure and 42. ,,
S-33 to 42 incl. ,,

T-33, 35, 36, 37, 38, 39 Failure.
U-40, 41 ,,
V-36, 37, 39, 42 ,,
V-40 Mechanical Hole.
X-33 to 42 incl. Failure.
Z-422, 423, 424 ,,
O-29 to 36 incl. ,,
Y* 7, 8, 9, ,,
SS-29, 30 ,,
XX-29, 30, 31, 32 ,,

—

AA-21 to 24 incl. Failure.
SS-29, 30, 31, 32 ,,
XX-29, 30, 31, 32 ,,
ZZ-8, 10, 14 ,,
A-32-Failure, also 31, 33, 34.
B-17, 18 ,,
C-11, 13, 14 Failure, also 12.
D-30, 31, 33, 34 Failure.
E-25, 26, 27, 28 ,,
M-32 ,,
S-29, 30, 31, 32 ,,
T-32 ,,
U-29, 30 ,,
V-29 ,,

, 1920.

PLATE IV.
PROC. AM. SOC. TEST. MATS.
VOL. XX, PART I.
REPORT OF COMMITTEE A-5:
CORROSION TESTS.

Weather *Heavy Overcast; Drizzle Rain.*

CONDITION OF RUST																									
Texture								Color									Adherence								
Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc.Adam 6	Mc.Donnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc.Adam 6	Mc.Donnell 7	Smith 8	Wheaton 9	Aupperle 1	Buck 2	Cooper 3	Fleming 4	Gibboney 5	Mc.Adam 6	Mc.Donnell 7	Smith 8	Wheaton 9
S	S	M	S	C	S	M	S	–	D	D	D	D	D	D	D	D	–	T	TL	T	T	L	T	L	T
S	S	M	S	C	S	M	S	D	D	D	D	D	D	D	D	D	T	T	TL	T	T	L	T	L	T
S	S	M	S	C	S	M	S	–	D	D	D	D	D	D	D	D	–	T	TL	T	T	L	T	L	T
S	S	M	S	C	S	M	S	–	D	D	D	D	D	D	D	D	–	T	TL	T	T	L	T	L	T
S	S	M	S	C	S	M	S	–	D	D	D	D	D	D	D	D	–	T	TL	T	T	L	T	L	T
S	S	M	S	C	S	M	S	–	D	D	D	D	D	D	D	D	–	T	TL	T	T	L	T	L	T
S	S	M	S	C	S	M	S	–	D	D	D	D	D	D	D	D	–	T	TL	T	T	L	T	L	T
S	S	M	S	C	S	M	S	D	D	D	D	D	D	D	D	D	T	T	TL	T	T	L	T	L	T
S	S	M	S	C	S	M	S	D	D	D	D	D	D	D	D	D	T	T	TL	T	T	L	T	L	T
S	S	M	S	C	S	M	S	D	D	D	D	D	D	D	D	D	T	T	TL	T	T	L	T	L	T
S	M	M	S	C	M	M	M	D	D	D	D	D	D	D	M	D	T	TL	TL	T	T	L	T	L	T
S	M	M	S	C	M	M	M	D	D	D	D	D	D	D	M	D	T	TL	TL	T	T	L	T	L	T
S	M	M	S	C	M	M	M	D	D	D	D	D	D	D	M	D	T	TL	TL	T	T	L	T	L	T
S	M	M	S	C	M	M	M	D	D	D	D	D	D	D	M	D	T	TL	TL	T	T	L	T	L	T
S	M	M	S	C	M	M	M	D	D	D	D	D	D	D	M	D	T	TL	TL	T	T	L	T	L	T
S	M	M	S	C	M	M	M	D	D	D	D	D	D	D	M	D	T	TL	TL	T	T	L	T	L	T
S	M	M	S	C	M	M	M	D	D	D	D	D	D	D	M	D	T	TL	TL	T	T	L	T	L	T
S	M	M	S	C	M	M	M	–	D	D	D	D	D	D	M	D	–	TL	TL	T	T	L	T	L	T
S	M	M	M	C	M	M	M	–	D	D	D	D	D	D	M	D	–	TL	TL	T	T	L	T	L	T
S	M	M	M	C	M	M	M	D	D	D	D	D	D	D	M	D	T	TL	TL	T	T	L	T	L	T
	S	M	M	C	M	M	M	D	D	D	D	D	D	D	M	D	T	TL	T	T	T	L	T	L	T
	S	M	M	C	M	M	M	D	D	D	D	D	D	D	M	D	T	TL	T	T	T	L	T	L	T
	S	M	M	C	M	M	M	D	D	D	D	D	D	D	M	D	T	TL	T	T	T	L	T	L	T
	S	M	M	C	M	M	M	–	D	D	D	D	D	D	M	D	–	TL	T	T	T	L	T	L	T
	S	M	M	C	M	M	M	–	D	D	D	D	D	D	M	D	–	TL	T	T	T	L	T	L	T
	S	M	M	C	M	M	M	D	D	D	D	D	D	D	M	D	T	TL	T	T	T	L	T	L	T
	S	M	M	C	M	M	M	–	D	D	D	D	D	D	M	D	–	TL	T	T	T	L	T	L	T
	S	M	M	C	M	M	M	D	D	D	D	D	D	D	M	D	T	TL	T	T	T	L	T	L	T
	S	M	M	C	M	M	M	D	D	D	D	D	D	D	M	D	T	TL	T	T	T	L	T	L	T
	S	M	M	C	M	M	M	–	D	D	D	D	D	D	M	D	–	TL	T	T	T	L	T	L	T
	–	VC	–	VC	–	–	VC	–	–	–	L	–	M	–	–	M	–	–	–	L	–	L	–	L	L
	–	VC	–	VC	–	–	VC	–	–	–	L	–	M	–	–	M	–	–	–	L	–	L	–	L	L
	–	VC	–	VC	–	–	VC	–	–	–	L	–	M	–	–	M	–	–	–	L	–	L	–	–	L
	–	VC	–	VC	–	–	VC	–	–	–	L	–	M	–	–	M	–	–	–	L	–	L	–	–	L
	–	VC	–	VC	–	–	VC	–	–	–	L	–	M	–	–	M	–	–	–	L	–	L	–	–	L
	–	VC	–	VC	–	–	VC	–	–	–	L	–	M	–	–	M	–	–	–	L	–	L	–	–	L
	–	VC	–	VC	–	–	VC	–	–	–	L	–	M	–	–	M	–	–	–	L	–	L	–	–	L
	–	VC	–	VC	–	–	VC	–	–	–	L	–	M	–	–	M	–	–	–	L	–	L	–	–	L
	–	VC	–	VC	–	–	VC	–	–	–	L	–	M	–	–	M	–	–	–	L	–	L	–	–	L
	–	VC	–	VC	–	–	VC	–	–	–	L	–	M	–	–	M	–	–	–	L	–	L	–	–	L
	VS	VS	S	M	VS	VS	VS	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	T	T
	–	VC	S	VC	–	–	C	L	–	–	L	D	M	–	–	M	L	–	–	L	T	L	–	–	L
	–	VC	S	VC	–	–	C	L	–	–	L	D	M	–	–	M	L	–	–	L	T	L	–	–	L
	–	VC	S	VC	–	–	C	L	–	–	L	D	M	–	–	M	L	–	–	L	T	L	–	–	L
	S	S	M	C	S	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	VS	S	M	C	S	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	VS	S	M	C	S	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	VS	S	M	M	S	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	VS	S	M	M	S	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	VS	S	M	M	S	S	S	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	VS	S	M	M	S	VS	VS	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	VS	S	M	M	S	VS	VS	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	VS	S	M	M	S	VS	VS	D	D	D	D	D	D	D	D	D	T	T	T	T	T	L	T	L	T
	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
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	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	–	VC	C	VC	–	C	C	–	–	–	L	M	M	–	M	M	–	–	–	L	L	L	–	L	T
	–	VC	C	VC	–	C	C	–	–	–	L	M	M	–	M	M	–	–	–	L	L	L	–	L	T
	–	VC	C	VC	–	C	C	–	–	–	L	M	M	–	M	M	–	–	–	L	L	L	–	L	T
	VC	VC	C	VC	VC	VC	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
	VC	VC	C	VC	VC	VC	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L
	VC	VC	C	VC	VC	VC	VC	L	L	L	L	M	M	L	L	M	L	L	L	L	L	L	L	L	L

— M. E. Mc.DONNELL —

AA – 21,22,23,24 - Failure.
EE* – 13,14,15,16 - Adherence Approaching loose.
SS – 29,30,31,32 - Failure at Lower End of Sheets.
XX – 29,30,31,32 – " " " " " "
ZZ – 8,10,14 - Old Failures.
A – 31,32,33,34 " " .
B – 17,18 - Failures; One Hole.
C – 11 - Failure; Three Holes.
C – 13,14 - " ; Two " .
D – 30,31,33,34 - Old Failures.
E – 25,26,27,28 - " " .
M – 29,30,31 - Adherence Approaching tight.
M – 32 – Failure; One Hole.
S – 29,30,31,32 - Old Failures.

T – 32 - Failure; One Hole.
U – 29,30 - " ; " " .
V – 29 - " ; Two Holes.
X – 29,30,31,32 - Old Failures.
O – 25,26,27,28 - " " .
Z – 6, 7, 11 - " " .
AA – 25 to 30 incl. - " " .
AA* – 50 " 56 " . " " .
BB* – 33,34,35,36,50,51,52,53 - Adherence Approaching tight.
SS – 33,35,39,40 - Failed at Lower End.
XX – 41 - " " " " .
A – 35 to 47 incl. – Old Failures.
B – 21,22,23 - Adherence Approaching tight.
B – 35,36,37,38 - Old Failures.

C – 20,21,22,32,34,35 – Old Failures.
D – 35,36,38,39,40 – " " .
E – 29, 36 – " " .
M – 33 to 42 incl. - Color of all Ten Sheets Approaching Med. and Tex.
M – 36 - Failure. Approaching tight.
S – 33 to 42 incl. – Old Failures.
T – 33,35,36,37,38,39 - Failure; Adherence of all Approaching tight.
U – 40, 41 - Failures; " " " " loose.
V – 36,37,39,42 - Failure; V-40 Accidental Hole; Adh. of all " "
X – 33 to 42 incl. - Old Failures.
Z – 422,423,424. – " " .
O – 29 to 36 incl. - " " .
Y – 7, 8, 9 – " " .
M – 36, 42 – Failure.

— H. E. SMITH —

AA – 21,22,23,24 - Failure.
A – 31,32,33,34 " .
D – 30,31,33,34 " .
T – 32 - Hole near Bottom.
X – 29,30,31,32 - Failure.
AA – 25 to 30 incl. - " .
XX – 41 - Failed at Bottom.
C – 20,21,22,32,33,34,35,36 - Failure.
I – 50 - Bullet Hole
T – 33,35,36,37,38,39 – Failure.
V – 40 – Mechanically Injured.
O – 29 to 36 incl. - Failures.
Y – 7,8,9 - Failure at Bottom.
XX – 29,30,31,32 - " " " .

SS – 32 - Failure.
B – 17,18 - " .
M – 32 - " .
U – 29,30 - " .
O – 25,26,27,28 - Failure.
AA* – 50 to 56 incl. - " .
A – 35 " 47 " " .
D – 35,36,38,39,40 - " .
M – 36, 42 - " .
U – 40, 41 – " .
X – 32 to 42 incl. " .
Z – 422,423,424 - Failures.
SS – 29,30,31 - " .
E – 25,26,27,28 " .

ZZ – 8,10,14 – Failure.
C – 11,13,14 – " .
S – 29,30,31,32 - " .
V – 29 - Holes; " .
Z – 6,7,11 - " .
SS – 33,35,39,40 - " .
B – 35,36,37,38 - " .
E – 29 to 36 incl. " .
S – 33 " 42 " . " .
V – 36,37,39,42 - " .

— F. B. WHEATON —

AA – 21,22,23,24 - Failure.
ZZ – 8,10,14 - " .
C – 11-13-14 " .
M – 32 - " .
U – 29,30 " .
O – 25,26,27,28 " .
AA* – 50 to 56 incl. " .
A – 35 " .
M – 36,42 " .
U – 40,41 " .
X – 33 " .
Y – 7,8,9 " .
XX – 29,30,31,32 " .

CC – 17 - Destroyed.
A – 31,32,33,34 - Failure.
D – 30,31,33,34 - " .
S – 29,30,31,32 " .
V – 29 " .
Z – 6,7,11 " .
SS – 33,35,39,40 " .
B – 35,36,37,38 " .
E – 29 to 36 incl. " .
S – 33 " 42 " . " .
V – 36,37,39,42 " .
Z – 422,423,424 " .
A – 36 to 47 incl. " .
X – 34 " 42 " . " .

SS – 32 - Failure; also Failure of 29,30 & 31.
B – 17,18 - " .
E – 25,26,27,28 Failure.
T – 32 " .
X – 29,30,31,32 " .
AA – 25 to 30 incl. " .
XX – 41 " .
C – 20,21,22,32,34,35 " .
I – 50 - Bullet Hole. " .
T – 33,35,36,37,38,39 " .
~~V~~ – 40 - Bullet Hole. " .
O – 29 to 36 incl. " .
D – 35,36,38,39,40 " .

G —
Failure. T-33,35,36,37,38,39 Failure.
" U-40,41 "
0 " V-36,37,39,42 "
" V-40 Mechanical Hole.
" X-33 to 42 incl. Failure.
" Z-422,423,424 "
" O – 29 to 36 incl. "
" Y* 7, 8, 9, "
5 " SS – 29, 30 "
" XX – 29,30,31,32 "
"
"
42. "
"

— J. H. GIBBONEY —

AA – 21 to 24 incl. Failure.
SS – 29,30,31,32 "
XX – 29,30,31,32 "
ZZ – 8, 10, 14 "
A – 32 - Failure, also 31,33,34.
B – 17, 18 " .
C – 11, 13, 14 Failure, also 12.
D – 30,31,33,34 Failure.
E – 25,26,27,28 "
M – 32 "
S – 29,30,31,32 "
T – 32 "
U – 29,30 "
V – 29 "

X – 29,30,31,32 - Failure.
O – 25,26,27,28 "
Z – 6, 7, 11 "
AA – 25,26,27,28,29,30 "
AA* – 50 to 56 incl. "
SS – 33, 35, 39,40 "
XX – 41 - "
A – 35 to 47 incl. "
B – 35 " 38 " "
C – 20,21,22,32,34,35 - Failures.
D – 35,36,38,39, 40 - Failure.
E – 29 to 36 incl. "
M – 36,42 - "
S – 33 to 42 incl. "

T – 33,35 to 39 incl. Failure.
U – 40,41 - "
V – 36,37,39,42 "
X – 33 to 42 incl. "
Z – 422,423,424 "
O – 29 to 36 incl. "
Y* – 7,8,9 "

— D. J. Mc.ADAM, JR. —

AA – 21 to 24 incl. Failed at Bottom.
SS – 32 - Failure, also Fail. of 29,30,31.
ZZ – 8,10,14 Failure at Bottom.
A – 31 to 34 incl. ⅓ gone.
B – 17, 18 - Holes.
C – 11,13,14 - " .
D – 30,31, 33,34 Failed at Bottom.
E – 25,26,27,28 - Holes.
M – 32 - Hole.
S – 29,30,31,32 - ½ gone.
T – 32 - Hole.
U – 29,30 - Holes.
V – 29 - Holes.
X – 29,30,31,32 - ⅓ gone.

O – 25,26,27,28 - Failed.
Z – 6, 7, 11 - Failed.
AA – 25 to 30 incl. - Failure.
AA* – 50 to 56 - Failed.
SS – 33,35,39,40 - " .
XX – 41 " .
A – 35 to 47 incl. " .
B – 35,36,37,38 - Holes.
C – 20,22,32,34,35 - " .
E – 29 to 36 incl. " .
M – 36, 42 – " .
S – 33 to 42 incl. ⅓ gone.
T – 33,35,36,37,38,39 - Holes.
U – 40, 41 - Holes.

V – 36, 37, 39,42 - Holes.
X – 33 to 42 incl. - Failed.
Z – 422, 423, 424 - Holes.
O – 29 to 36 incl. - Failure.
Y – 7,8,9 - Holes at Bottom.
XX – 29,30,31,32 - Failure.
C – 21 - Holes.
D – 35,36,38,39,40 - Failure.

James H. Gibboney
Chairman Inspection Committee

as failed at the November 5, 1919, inspection. The photographic record made at the November 5, 1919, inspection was unsatisfactory and its reproduction has been omitted.

Figs. 61 to 65, inclusive, represent the condition of sheets SS 29 and 30, 31 and 32, 33 and 34, 35 and 36, 39 and 40 (No. 16 Gage Low-Copper Pure Iron, Series B), manufactured by the American Rolling Mill Co. Sheets SS 29, 30, 31, 32, 33, 35, 39 and 40 have failed due to holes and ragged edges at lower ends. Sheets SS 34 and 36 have not failed.

Fig. 66 represents the condition of sheets XX 41 and 42, (No. 16 Gage Low-Copper Pure Iron, Series B), manufactured by the Inland Steel Co. Sheet XX 41 has failed due to holes and ragged edges at lower end. Sheet XX 42 has not failed.

Sheets XX 29, 30, 31 and 32 (No. 16 Gage Low-Copper Pure Iron, Series B), manufactured by the Inland Steel Co., have failed due to holes and ragged edges at lower ends. No photographic record was made of these sheets at this inspection due to inability, because of location, to place a photographic tower between the sheets and the wall of an adjacent building.

Sheets ZZ 8, 10 and 14 (No. 16 Gage Law-Copper Bessemer Steel, Series B), manufactured by the Youngstown Sheet and Tube Co., have failed due to holes and ragged edges at lower ends. No photographic record was made of these sheets at this inspection, due to inability, because of location, to place a photographic tower between the sheets and the wall of an adjacent building.

Following the same general plan of presenting condensed results of various inspections, as appearing in previous reports of the sub-committee, tables have been prepared from the composite reports for the inspections made during the past year.

Tables V, VI, VII and VIII give in condensed form the results obtained by the averaging method for the condition of surfaces of sheets at Pittsburgh and Annapolis in November, 1919, and at Fort Sheridan and Pittsburgh in May, 1920.

Table IX presents in condensed form the results obtained by the averaging method for the condition of surface texture of the sheets at Pittsburgh for all inspections. By comparing this information with rate of failures at this location shown in Table X it will be observed that the condition of surface texture

TABLE V.—PITTSBURGH TESTS. INSPECTION OF NOVEMBER 5, 1919.

Type Designation.	Average Texture.		Color.	Adherence.
	Numerical Value.	Symbol.		
No. 16 Gage.				
II	4.666	VS	D	T
ZZ (HC)	4.389	VS	D	T
KK	4.140	S	D	T
HH	4.044	S	D	T
EE	4.028	S	D	T
TT	3.690	S	D	T
VV	3.538	S	D	T
UU	3.524	S	D	T
CCC	3.333	M	D	T
BB	3.010	M	D	T
MM	2.405	C	D	T
CC	2.167	C	M	L
ZZ (LC)	2.067	C	L	L
OO	1.833	C	M	L
DD	1.528	VC	M	L
YY	1.333	VC	M	L
AA	1.143	VC	L	L
XX	1.119	VC	M	L
SS	1.000	VC	L	L
No. 22 Gage.				
Z (HC)	4.294	VS	D	T
I	4.092	S	D	T
K	3.833	S	D	T
T	3.619	S	D	T
U	3.548	S	D	T
H	3.444	S	D	T
V	3.286	M	D	T
M	3.238	M	D	T
E	3.062	M	D	T
B	2.808	M	D	T
C	2.606	M	D	T
Y	1.667	VC	M	L
Z (LC)	1.000	VC	M	L

NOTE.—All of the A, D, O, S and X sheets exposed at Pittsburgh, Pa., were recorded as complete failures in the 1919 report, no further detail record appearing.

ZZ (HC) indicates copper 0.153 to 0.586 per cent.
ZZ (LC) indicates copper 0.034 per cent or under.
Z (HC) indicates copper 0.128 to 0.712 per cent.
Z (LC) indicates copper 0.019 per cent or under.

The above table has been compiled from the composite inspection report by averaging the reports on texture on each sheet by each inspector. The arbitrary figures used in these averages are as follows:

Very coarse	1
Coarse	2
Medium	3
Smooth	4
Very smooth	5

The numerical values thus obtained have been translated back into symbols, using the following scale:

1.0 to 1.8	Very coarse (VC)
1.8 to 2.6	Coarse (C)
2.6 to 3.4	Medium (M)
3.4 to 4.2	Smooth (S)
4.2 to 5.0	Very smooth (VS)

In the case of color and adherence, it being impractical to ascribe satisfactory numerical values, the symbols in the table represent the majority opinions of the inspectors.

TABLE VI.—ANNAPOLIS TESTS. INSPECTION OF NOVEMBER 6, 1919.

Type Designation.	Average Texture.		Color.	Adherence.
	Numerical Value.	Symbol.		
	No. 16 GAGE.			
II	3.938	S	D	T
KK	3.667	S	D	T
ZZ (HC)	3.602	S	M	T
TT	3.480	S	M	T
EE	3.286	M	M	T
HH	3.277	M	M	T
BB	3.252	M	M	T
MM	3.031	M	M	T
UU	2.969	M	M	T
DD	2.917	M	M	T
VV	2.826	M	M	L
ZZ (LC)	2.762	M	M	T
OO	2.429	C	M	L
CCC	2.417	C	M	T
CC	2.357	C	M	T
XX	2.204	C	L	L
AA	2.095	C	L	L
YY	1.857	C	L	L
SS	1.827	C	L	L
	No. 22 GAGE			
I	4.027	S	D	T
K	3.741	S	D	T
Z (HC)	3.635	S	M	T
H	3.339	M	M	T
T	3.173	M	D	T
E	3.156	M	M	T
B	2.845	M	M	T
M	2.775	M	M	T
U	2.714	M	M	T
V	2.520	C	M	T
C	2.500	C	L	L
Z (LC)	2.286	C	M	L
D	2.265	C	L	L
A	2.228	C	M	T
X	2.112	C	L	L
Y	2.000	C	L	L
O	1.893	C	M	L
S	1.888	C	L	L

NOTE.—ZZ (HC) indicates copper 0.162 to 0.662 per cent.
ZZ (LC) indicates copper 0.034 per cent or under.
Z (HC) indicates copper 0.138 to 0.654 per cent.
Z (LC) indicates copper 0.020 per cent or under.

The above table has been compiled from the composite inspection report by averaging the reports on texture on each sheet by each inspector. The arbitrary figures used in these averages are as follows:

Very coarse	1
Coarse	2
Medium	3
Smooth	4
Very smooth	5

The numerical values thus obtained have been translated back into symbols, using the following scale:

1.0 to 1.8	Very coarse (VC)
1.8 to 2.6	Coarse (C)
2.6 to 3.4	Medium (M)
3.4 to 4.2	Smooth (S)
4.2 to 5.0	Very smooth (VS)

In the case of color and adherence, it being impractical to ascribe satisfactory numerical values, the symbols in the table represent the majority of opinions of inspectors.

TABLE VII.—FORT SHERIDAN TESTS. INSPECTION OF MAY 10, 1920.

Type Designation.	Average Texture.		Color.	Adherence.
	Numerical Value.	Symbol.		
No. 16 Gage.				
KK	4.085	S	D	T
ZZ(HC)	4.023	S	D	T
II	3.934	S	D	T
HH	3.625	S	D	T
TT	3.580	S	D	T
BB	3.470	M	D	L
EE	3.281	M	D	T
UU	3.279	M	M	T
VV	3.099	M	D	T
MM	2.929	M	D	L
CCC	2.750	M	M	T
CC	2.635	M	L	T
ZZ(LC)	2.500	C	M	L
DD	2.474	C	M	T
XX	2.330	C	M	L
OO	2.281	C	M	L
SS	2.250	C	L	L
YY	2.125	C	L	L
AA	1.368	VC	L	L
No. 22 Gage.				
Z(HC)	4.114	S	D	T
I	4.125	S	D	T
K	4.047	S	D	T
H	3.716	S	D	T
T	3.545	S	D	T
M	3.468	M	D	T
V	3.295	M	M	T
E	3.219	M	D	T
B	3.096	M	M	T
U	3.071	M	M	T
C	2.844	M	M	T
Y	2.375	C	M	L
D	2.313	C	L	L
X	2.098	C	L	L
Z(LC)	2.000	C	L	L
S	1.946	C	L	L
A	1.564	VC	L	L
O	1.386	VC	L	L

NOTE.—ZZ(HC) indicates copper 0.154 to 0.658 per cent.
ZZ(LC) indicates copper 0.031 per cent or under.
Z(HC) indicates copper 0.126 to 0.554 per cent.
Z(LC) indicates copper 0.020 per cent or under.

The above table has been compiled from the composite inspection report by averaging the reports on texture on each sheet by each inspector. The arbitrary figures used in these averages are as follows:

Very coarse	1
Coarse	2
Medium	3
Smooth	4
Very smooth	5

The numerical values thus obtained have been translated back into symbols, using the following scale:

1.0 to 1.8	Very coarse (VC)
1.8 to 2.6	Coarse (C)
2.6 to 3.4	Medium (M)
3.4 to 4.2	Smooth (S)
4.2 to 5.0	Very smooth (VS)

In the case of color and adherence, it being impractical to ascribe satisfactory numerical values, the symbols in the table represent the majority opinions of the inspectors.

TABLE VIII.—PITTSBURGH TESTS. INSPECTION OF MAY 11, 1920.

Type Designation.	Average Texture.		Color.	Adherence.
	Numerical Value.	Symbol.		
No. 16 GAGE.				
II	4.358	VS	D	T
ZZ(HC)	4.333	VS	D	T
KK	4.053	S	D	T
HH	3.896	S	D	T
EE	3.722	S	D	T
TT	3.666	S	D	T
UU	3.492	S	D	T
VV	3.393	M	D	T
CCC	3.074	M	D	T
BB	2.752	M	D	L
MM	2.222	C	M	L
CC	2.065	C	M	L
OO	1.407	VC	L	L
DD	1.296	VC	L	L
YY	1.111	VC	L	T
No. 22 GAGE.				
I	4.136	S	D	T
Z(HC)	4.131	S	D	T
K	4.083	S	D	T
H	3.777	S	D	T

NOTE.—In the case of all of the A, D, O, S and X sheets exposed at Pittsburgh, Pa., recorded as complete failures in the 1919 report, no further detail records appear. All of the E, Y and AA sheets and a number of the B, C, M, T, U, V, Z (Low Copper), SS, XX, and ZZ (Low Copper) sheets exposed at Pittsburgh, Pa.; are recorded as failures in this report, therefore no rating appears in this table.

ZZ(HC) indicates copper 0.153 to 0.586 per cent.
ZZ(LC) indicates copper 0.034 per cent or under.
Z(HC) indicates copper 0.128 to 0.712 per cent.
Z(LC) indicates copper 0.019 per cent or under.

The above table has been compiled from the composite inspection report by averaging the reports on texture on each sheet by each inspector. The arbitrary figures used in these averages are as follows:

Very coarse	1
Coarse	2
Medium	3
Smooth	4
Very smooth	5

The numerical values thus obtained have been translated back into symbols, using the following scale:

1.0 to 1.8	Very coarse (VC)
1.8 to 2.6	Coarse (C)
2.6 to 3.4	Medium (M)
3.4 to 4.2	Smooth (S)
4.2 to 5.0	Very smooth (VS)

In the case of color and adherence, it being impractical to ascribe satisfactory numerical values, the symbols in the table represent the majority opinions of the inspectors.

TABLE IX.—AVERAGE SURFACE TEXTURE, PITTSBURGH TESTS. INSPECTIONS OF 1917, 1918, 1919 AND 1920. SHEETS EXPOSED DECEMBER 12, 1916.

NO. 16 GAGE.

Group.	Type Designation.	Date of Inspection.											
		Oct. 9, 1917.		Apr. 9, 1918.		Oct. 7, 1918.		April 1, 1919.		Nov. 5, 1919.		May 11 1920.	
		Numerical Value.	Symbol.	Numerical Value.	Symbol.	Numerical Value.	Symbol.	Numerical Value.	Symbol.	Numerical Value.	Symbol.	Numerical Value.	Symbol.
HH	Copper-bearing Basic Open-Hearth Steel, Series A	3.725	S	3.600	S	4.025	S	3.883	S	4.044	S	3.896	S
ZZ (HC)	Copper-bearing Steel, Series B. Youngstown Sheet and Tube Co	3.684	S	4.266	VS	4.500	VS	4.267	VS	4.389	VS	4.333	VS
II	Copper-bearing Bessemer Steel, Series A	3.597	S	4.389	VS	4.431	VS	4.271	VS	4.666	VS	4.358	VS
TT	Copper-bearing Steel, Series B. Newport Rolling Mill Co	3.572	S	3.589	S	3.982	S	4.071	S	3.690	S	3.666	S
KK	Copper-bearing Acid Open-Hearth Steel, Series A	3.428	S	4.171	VS	4.177	S	4.178	S	4.140	S	4.053	S
UU	Copper-bearing Pure Iron, Series B. Allegheny Steel Co	3.339	M	3.518	S	3.839	S	3.907	S	3.524	S	3.492	S
CCC	Copper-bearing Pure Iron, Series A	3.219	M	3.333	M	3.333	M	3.130	M	3.333	M	3.074	M
EE	Puddled Iron, Series A	3.208	M	3.542	S	3.813	S	3.792	S	4.028	S	3.722	S
BB	Open-Hearth Steel, Series A	3.100	M	3.037	M	2.860	M	2.941	M	3.010	M	2.752	M
VV	Copper-bearing Pure Iron, Series B. Whitaker-Glessner Co	3.087	M	3.529	S	3.923	S	3.910	S	3.538	S	3.393	M
YY[a]	Low-Copper Wrought Iron. Series B. Youngstown Sheet Tube Co	.....		3.000	M	2.600	C	1.625	VC	1.333	VC	1.111	VC
CC	Copper-bearing Pure Iron, Series A	2.970	M	2.812	M	2.625	M	2.344	C	2.167	C	2.065	C
MM	Open-Hearth Steel, Series B. Alan Wood Iron and Steel Co.	2.857	M	2.357	C	2.804	M	2.536	C	2.405	C	2.222	C
DD	Low-Copper Pure Iron, Series A	2.521	C	2.215	C	2.139	C	1.409	VC	1.528	VC	1.296	VC
OO	Low-Copper Open-Hearth Steel, Series A	2.167	C	1.500	VC	2.083	C	1.708	VC	1.833	C	1.407	VC
ZZ (LC)	Low-Copper Steel, Series B. Youngstown Sheet and Tube Co	2.150	C	1.600	VC	2.375	C	1.450	VC	2.067	C	.....	
XX	Low-Copper Pure Iron, Series B. Inland Steel Co	1.996	C	1.750	VC	1.643	VC	1.482	VC	1.119	VC	.....	
SS	Low-Copper Pure Iron, Series B. American Rolling Mill Co	1.822	C	1.625	VC	1.125	VC	1.000	VC	1.000	VC	.....	
AA	Bessemer Steel, Series A	1.162	VC	1.000	VC	1.037	VC	1.000	VC	1.143	VC	.....	

NOTE.—ZZ(HC) indicates copper 0.153 to 0.586 per cent.
ZZ(LC) incidates copper 0.034 per cent or under.

[a] YY Sheets exposed June 2, 1917.

TABLE IX (*continued*).

NO. 22 GAGE.

Group.	Type Designation.	Date of Inspection.											
		Oct. 9, 1917.		April 9, 1918.		Oct. 7, 1918.		Apr. 1, 1919.		Nov. 5, 1919.		May 11, 1920.	
		Numerical Value.	Symbol.	Numerical Value.	Symbol.	Numerical Value.	Symbol.	Numerical Value.	Symbol.	Numerical Value.	Symbol.	Numerical Value.	Symbol.
Z (HC)	Copper-bearing Steel, Series B. Youngstown Sheet and Tube Co	3.828	S	4.008	S	4.294	VS	4.522	VS	4.294	VS	4.131	S
I	Copper-bearing Bessemer Steel, Series A	3.819	S	4.118	S	4.472	VS	4.084	S	4.092	S	4.136	S
H	Copper-bearing Basic Open-Hearth Steel, Series A	3.792	S	3.572	S	4.000	S	3.958	S	3.444	S	3.777	S
K	Copper-bearing Acid Open-Hearth Steel, Series A	3.719	S	4.062	S	4.187	S	4.188	S	3.833	S	4.083	S
B	Open Hearth Steel, Series A	3.653	S	3.211	M	3.567	S	3.202	M	2.808	M	....	....
T	Copper-bearing Steel, Series B. Newport Rolling Mill Co	3.589	S	3.482	S	4.107	S	3.821	S	3.619	S	....	....
U	Copper-bearing Pure Iron, Series B. Allegheny Steel Co	3.554	S	3.232	M	3.875	S	3.696	S	3.548	S	....	....
V	Copper-bearing Pure Iron, Series B. Whitaker-Glessner Co	3.464	S	3.304	S	3.839	S	3.536	S	3.286	M	....	....
Y[a]	Low-Copper Wrought Iron, Series B. Youngstown Sheet and Tube Co	....	....	3.250	M	2.500	C	1.625	VC	1.667	VC	....	....
C	Copper-bearing Pure Iron, Series A	3.364	M	2.864	M	3.273	M	3.204	M	2.606	M	....	....
M	Open-Hearth Steel, Series B. Alan Wood Iron and Steel Co	3.330	M	3.107	M	2.732	M	3.108	M	3.238	M	....	....
E	Puddled Iron, Series A	3.125	M	3.250	M	3.385	M	3.270	M	3.062	M	....	....
D	Low-Copper Pure Iron, Series A	2.431	C	1.833	C	1.667	VC	1.333	VC	....	....	....	....
Z (LC)	Low-Copper Steel, Series B. Youngstown Sheet and Tube Co	2.142	C	1.803	C	1.813	C	1.187	VC	1.000	VC	....	....
S	Low-Copper Pure Iron, Series B. American Rolling Mill Co	1.893	C	1.625	VC	1.000	VC	1.000	VC	....	....	....	....
X	Low-Copper Pure Iron, Series B. Inland Steel Co	1.491	VC	1.268	VC	1.214	VC	1.125	VC	....	....	....	....
A	Bessemer Steel, Series A	1.346	VC	1.000	VC	1.125	VC	1.029	VC	....	....	....	....
O	Low-Copper Open-Hearth Steel, Series A	1.209	VC	1.000	VC	1.091	VC	1.167	VC	....	....	....	....

NOTE.—Z(HC) indicates copper 0.128 to 0.712 per cent.
Z(LC) indicates copper 0.019 per cent or under.

[a] Y Sheets exposed June 2, 1917.

In the case of all of the A, D, O, S and X sheets exposed at Pittsburgh, Pa., recorded as complete failures in the 1919 report, no further detail records appear. All of the E, Y and AA sheets, and a number of the B, C, M, T, U, V, Z (Low Copper), SS, XX, and ZZ (Low Copper) sheets exposed at Pittsburgh, Pa., are recorded as failures in this report, therefore no rating appears in this table.

Table IX has been compiled from the composite inspection reports by averaging the reports on texture on each sheet by each inspector. The arbitrary figures used in these averages are as follows:

Very coarse	1
Coarse	2
Medium	3
Smooth	4
Very smooth	5

The numerical values thus obtained have been translated back into symbols, using the following scale:

1 : 0 to 1 : 8	Very coarse (VC)
1 : 8 to 2 : 6	Coarse (C)
2 : 6 to 3 : 4	Medium (M)
3 : 4 to 4 : 2	Smooth (S)
4 : 2 to 5 : 0	Very smooth (VS)

appears to be a reliable guide as regarding rate of corrosion, the coarseness of texture being apparently directly proportional to increased rate of corrision.

Table X is presented as showing all sheets at the Pittsburgh location grouped as regarding the presence of copper into copper-bearing and non-copper-bearing metals, the average analysis of all sheets at all three locations being the basis for classification. The table also shows the failures as recorded at all inspection periods, the lengths of exposure being 10, 16, 22, 28, 35, and 41 months respectively, from which it will be observed that the failures at this location have been confined mainly to the non-copper-bearing groups of metals.

TABLE XI.—AVERAGE COMPOSITIONS OF GROUPS OF SHEETS OF PITTSBURGH TESTS THAT HAVE COMPLETELY FAILED. SHEETS EXPOSED DECEMBER 12, 1916.

Group.	Type Designation.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.
A 31–47	No. 22 Gage Bessemer Steel, Series A......	0.037	0.38	0.089	0.040	0.006	0.010
D 30–40	No. 22 Gage Low-Copper Pure Iron, Series A	0.024	0.026	0.003	0.020	0.004	0.022
E 25–36	No. 22 Gage Puddled Iron, Series A........	0.035	0.03	0.111	0.020	0.125	0.30
O 25–36	No. 22 Gage Low-Copper Open-hearth Steel, Series A...........................	0.134	0.55	0.008	0.029	0.24	0.018
S 29–42	No. 22 Gage Low-Copper Pure Iron, Series B.—A. R. M. Co......................	0.018	0.018	0.005	0.025	0.004	0.023
X 29–42	No. 22 Gage Low-Copper Pure Iron, Series B.—Inland Steel Co.....................	0.021	0.057	0.006	0.031	0.002	0.025
Y[a] 7–9	Low-Copper Wrought Iron, Series B.—Youngstown Sheet and Tube Co........	0.03	0.006	0.156	0.020	0.23	0.023
AA 21–30	No. 16 Gage Bessemer Steel, Series A......	0.029	0.40	0.084	0.040	0.001	0.015
AA 50–56	" " " " "	0.006	0.42	0.088	0.043	0.003	0.007

[a] Y sheets exposed June 2, 1917.

Table XI is presented as showing in condensed form the average composition of groups of sheets which have completely failed at the Pittsburgh location. No further detail record for these sheets will appear in future reports.

Respectfully submitted on behalf of the sub-committee,

J. H. GIBBONEY,
Chairman.

TABLE X.—FAILURES AT PITTSBURGH TEST. INSPECTIONS OF 1917, 1918, 1919, AND MAY, 1920. SHEETS EXPOSED DECE

BEARING MATERIALS.[1]

No. 22 GAGE SHEETS.

Group.	Designation.	Series.	Description.	Average Analyses.						Number of Sheets in test.
				Carbon.	Manganese.	Phosphorus.	Sulfur.	Silicon.	Copper.	
B	Open-Hearth Steel	A	Copper-bearing	0.06	0.27	0.014	0.053	0.006	0.179	9
C	Copper-bearing Pure Iron	A	" "	0.015	0.028	0.006	0.036	0.003	0.190	9
E	Puddled Iron	A	" "	0.033	0.034	0.114	0.021	0.134	0.283	12
H	Copper-bearing Basic Open-Hearth Steel	A	" "	0.069	0.387	0.016	0.027	0.004	0.244	12
I	Copper-bearing Bessemer Steel	A	" "	0.041	0.365	0.097	0.068	0.008	0.252	18
K	Copper-bearing Acid Open-Hearth Steel	A	" "	0.107	0.447	0.091	0.046	0.004	0.237	16
M	Open-Hearth Steel, Alan Wood Iron and Steel Co	B	" "	0.093	0.419	0.013	0.041	0.011	0.185	14
T	Copper-bearing Steel, Newport Rolling Mill Co	B	" "	0.083	0.313	0.009	0.020	0.005	0.227	14
U	Copper-bearing Pure Iron, Allegheny Steel Co	B	" "	0.017	0.074	0.008	0.037	0.005	0.260	14
V	Copper-bearing Pure Iron, Whitaker-Glessner Co	B	" "	0.018	0.051	0.007	0.021	0.005	0.304	14
Z	Copper-bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	" "	0.039	0.37	0.084	0.038	0.007	0.257	3
Z	Copper-bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	" "	0.043	0.37	0.100	0.045	.....	0.533	2
Z	Copper-bearing Open-Hearth Steel, Youngstown Sheet and Tube Co.	B	" "	0.06	0.35	0.049	0.059	.....	0.212	3
Z	Copper-bearing Open-Hearth Steel, Youngstown Sheet and Tube Co.	B	" "	0.07	0.39	0.059	0.058	.....	0.268	3
Z	Copper-bearing Open-Hearth Steel, Youngstown Sheet and Tube Co.	B	" "	0.07	0.41	0.050	0.050	.....	0.621	3
A	Bessemer Steel	A	Non-Copper-bearing	0.038	0.386	0.089	0.040	0.007	0.014	17
B	Open-Hearth Steel	A	" " "	0.09	0.38	0.017	0.062	0.036	0.082	4
C	Copper-bearing Pure Iron	A	" " "	0.01	0.028	0.002	0.027	0.002	0.139	2
D	Low-copper Pure Iron	A	" " "	0.02	0.026	0.004	0.022	0.002	0.024	9
O	Low-copper Open-Hearth Steel	A	" " "	0.121	0.536	0.008	0.030	0.249	0.020	12
S	Low-copper Pure Iron, American Rolling Mill Co	B	" " "	0.02	0.023	0.006	0.022	0.004	0.022	14
X	Low-copper Pure Iron, Inland Steel Co	B	" " "	0.021	0.055	0.007	0.031	0.004	0.027	14
Y	Low-copper Wrought Iron, Youngstown Sheet and Tube Co	B	" " "	0.03	0.055	0.139	0.021	0.218	0.020	3
Z	Bessemer Steel, Youngstown Sheet and Tube Co	B	" " "	0.055	0.37	0.119	0.048	0.003	0.013	3
Z	Bessemer Steel, Youngstown Sheet and Tube Co	B	" " "	0.07	0.40	0.088	0.048	0.009	0.133	3
Z	Open-Hearth Steel, Youngstown Sheet and Tube Co	B	" " "	0.10	0.32	0.069	0.044	0.002	0.018	3

No. 16 GAGE SHEETS.

Group.	Designation.	Series.	Description.	Carbon.	Manganese.	Phosphorus.	Sulfur.	Silicon.	Copper.	Number of Sheets in test.
EE	Puddled Iron,	A	Copper-bearing	0.035	0.03	0.119	0.018	0.125	0.319	12
HH	Copper-bearing Basic Open-Hearth Steel	A	" "	0.074	0.373	0.011	0.026	0.004	0.237	15
II	Copper-bearing Bessemer Steel	A	" "	0.059	0.371	0.095	0.066	0.006	0.247	18
KK	Copper-bearing Acid Open-Hearth Steel	A	" "	0.108	0.433	0.085	0.043	0.005	0.234	19
CCC	Copper-bearing Pure Iron	A	" "	0.023	0.026	0.005	0.028	0.005	0.236	12
TT	Copper-bearing Steel, Newport Rolling Mill Co	B	" "	0.080	0.313	0.009	0.020	0.006	0.223	14
UU	Copper-bearing Pure Iron, Allegheny Steel Co	B	" "	0.018	0.066	0.008	0.028	0.005	0.239	14
VV	Copper-bearing Pure Iron, Whitaker-Glessner Co	B	" "	0.018	0.046	0.007	0.019	0.004	0.299	13
ZZ	Copper-bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	" "	0.08	0.40	0.092	0.037	0.004	0.153	1
ZZ	Copper-bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	" "	0.09	0.31	0.088	0.047	.....	0.271	3
ZZ	Copper-bearing Bessemer Steel, Youngstown Sheet and Tube Co	B	" "	0.07	0.36	0.085	0.033	.....	0.549	3
ZZ	Copper-bearing Open-Hearth Steel, Youngstown Sheet and Tube Co.	B	" "	0.06	0.37	0.054	0.064	.....	0.223	3
ZZ	Copper-bearing Open-Hearth Steel, Youngstown Sheet and Tube Co.	B	" "	0.09	0.33	0.032	0.056	0.003	0.575	3
ZZ	Copper-bearing Open-Hearth Steel, Youngstown Sheet and Tube Co.	B	" "	0.07	0.40	0.056	0.048	.....	0.364	2
AA	Bessemer Steel	A	Non-Copper-bearing	0.043	0.419	0.083	0.042	0.004	0.012	17
BB	Open-Hearth Steel	A	" " "	0.056	0.349	0.022	0.048	0.037	0.113	17
CC	Copper-bearing Pure Iron	A	" " "	0.019	0.029	0.004	0.032	0.003	0.067	12
DD	Low-copper Pure Iron	A	" " "	0.019	0.028	0.004	0.027	0.004	0.028	18
OO	Low-copper Open-Hearth Steel	A	" " "	0.108	0.371	0.009	0.029	0.007	0.029	12
MM	Open-Hearth Steel, Alan Wood Iron and Steel Co	B	" " "	0.107	0.414	0.010	0.029	0.007	0.057	14
SS	Low-copper Pure Iron, American Rolling Mill Co	B	" " "	0.017	0.021	0.006	0.021	0.006	0.025	14
XX	Low-copper Pure Iron, Inland Steel Co	B	" " "	0.021	0.062	0.008	0.030	0.005	0.028	14
YY	Low-copper Wrought Iron, Youngstown Sheet and Tube Co	B	" " "	0.03	0.051	0.123	0.019	0.203	0.023	3
ZZ	Bessemer Steel, Youngstown Sheet and Tube Co	B	" " "	0.07	0.40	0.097	0.037	0.008	0.013	3
ZZ	Open-Hearth Steel, Youngstown Sheet and Tube Co	B	" " "	0.032	0.40	0.044	0.028	.....	0.028	2

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[1] In preparing this table, sheets below 0.15 per cent copper have been considered as non-copper bearing, and those above 0.15 per cent as copper-bearing.

[2] These "Y" sheets were reported as failures at the Nov. 5, 1919, inspection, but are placed in this column because they were exposed about six months later than all ot

PLATE V.
PROC. AM. SOC. TEST. MATS.
VOL. XX, PART I.
REPORT OF COMMITTEE A-5:
CORROSION TESTS.

SPECTIONS OF 1917, 1918, 1919, AND MAY, 1920. SHEETS EXPOSED DECEMBER 12, 1916. COMPARING COPPER-BEARING WITH NON-COPPER-BEARING MATERIALS.[1]

No. 22 GAGE SHEETS.

	Series.	Description.	Average Analyses.						Number of Sheets in test.	Date of Inspection.					
			Carbon.	Manganese.	Phosphorus.	Sulfur.	Silicon.	Copper.		Oct. 9, 1917. 10 Months.	April 9, 1918. 16 Months.	Oct. 7, 1918. 22 Months.	April 1, 1919. 28 Months.	Nov. 5, 1919. 35 Months.	May 11, 1920. 41 Months.
......	A	Copper-bearing	0.06	0.27	0.014	0.053	0.006	0.179	9	None	None	None	None	17 (**1**)	18 (**1**)
......	A	" "	0.015	0.028	0.006	0.036	0.003	0.190	9	None	None	None	None	11, 13, 14 20, 22 (**5**)	32, 34, 35 (**3**)
......	A	" "	0.033	0.034	0.114	0.021	0.134	0.283	12	None	None	32, 36 (**2**)	29, 30, 31, 35 (**4**)	25, 27, 33, 34 (**4**)	26, 28 (**2**)
......	A	" "	0.069	0.387	0.016	0.027	0.004	0.244	12	None	None	None	None	None	None
......	A	" "	0.041	0.365	0.097	0.068	0.008	0.252	18	None	None	None	None	None	None
......	A	" "	0.107	0.447	0.091	0.046	0.004	0.237	16	None	None	None	None	None	None
......	B	" "	0.093	0.419	0.013	0.041	0.011	0.185	14	None	None	None	None	None	32, 36, 42 (**3**)
......	B	" "	0.083	0.313	0.009	0.020	0.005	0.227	14	None	None	None	None	37, 39 (**2**)	32, 33, 35 36, 38 (**5**)
......	B	" "	0.017	0.074	0.008	0.037	0.005	0.260	14	None	None	None	None	41 (**1**)	29, 30, 40 (**3**)
......	B	" "	0.018	0.051	0.007	0.021	0.005	0.304	14	None	None	None	None	29, 39 (**2**)	36, 37, 42 (**3**)
Co...	B	" "	0.039	0.37	0.084	0.038	0.007	0.257	3	None	None	None	None	None	None
Co...	B	" "	0.043	0.37	0.100	0.045	.....	0.533	2	None	None	None	None	None	None
be Co.	B	" "	0.06	0.35	0.049	0.059	.....	0.212	3	None	None	None	None	None	None
be Co.	B	" "	0.07	0.39	0.059	0.058	.....	0.268	3	None	None	None	None	None	None
be Co.	B	" "	0.07	0.41	0.050	0.050	.....	0.621	3	None	None	None	None	None	None
......	A	Non-Copper-bearing	0.038	0.386	0.089	0.040	0.007	0.014	17	None	31, 32, 33, 34, 35 36, 37, 38, 40, 41 42, 43, 44, 45, 46 47 (**16**)	39 (**1**)			
......	A	" " "	0.09	0.38	0.017	0.062	0.036	0.082	4	None	None	37 (**1**)	38 (**1**)	35 (**1**)	36 (**1**)
......	A	" " "	0.01	0.028	0.002	0.027	0.002	0.139	2	None	None	None	None	20 (**1**)	21 (**1**)
......	A	" " "	0.02	0.026	0.004	0.022	0.002	0.024	9	None	None	30, 36, 38 (**3**)	31, 33, 34, 35 39, 40 (**6**)		
......	A	" " "	0.121	0.536	0.008	0.030	0.249	0.020	12	None	25, 26, 27, 28, 29 30, 31, 32, 33, 34 35, 36 (**12**)				
......	B	" " "	0.02	0.023	0.006	0.022	0.004	0.022	14	None	35 (**1**)	29, 30, 31, 32, 33 34, 36, 37, 38, 39 40, 41, 42 (**13**)			
......	B	" " "	0.021	0.055	0.007	0.031	0.004	0.027	14	None	None	29, 30, 31, 32, 33 34, 35, 36, 37, 38 39, 40, 41, 42 (**14**)			
......	B	" " "	0.03	0.055	0.139	0.021	0.218	0.020	3	None	None	None	7, 8, 9 (**3**)[2]		
......	B	" " "	0.055	0.37	0.119	0.048	0.003	0.013	3	None	11 (**1**)	6, 7 (**2**)			
......	B	" " "	0.07	0.40	0.088	0.048	0.009	0.133	3	None	None	None	None	None	None
......	B	" " "	0.10	0.32	0.069	0.044	0.002	0.018	3	None	None	422, 423, 424 (**3**)			

No. 16 GAGE SHEETS.

	Series.	Description.	Carbon.	Manganese.	Phosphorus.	Sulfur.	Silicon.	Copper.	Number of Sheets in test.	Oct. 9, 1917. 10 Months.	April 9, 1918. 16 Months.	Oct. 7, 1918. 22 Months.	April 1, 1919. 28 Months.	Nov. 5, 1919. 35 Months.	May 11, 1920. 41 Months.
......	A	Copper-bearing	0.035	0.03	0.119	0.018	0.125	0.319	12	None	None	None	None	None	None
......	A	" "	0.074	0.373	0.011	0.026	0.004	0.237	15	None	None	None	None	None	None
......	A	" "	0.059	0.371	0.095	0.066	0.006	0.247	18	None	None	None	None	None	None
......	A	" "	0.108	0.433	0.085	0.043	0.005	0.234	19	None	None	None	None	None	None
......	A	" "	0.023	0.026	0.005	0.028	0.005	0.236	12	None	None	None	None	None	None
......	B	" "	0.080	0.313	0.009	0.020	0.006	0.223	14	None	None	None	None	None	None
......	B	" "	0.018	0.066	0.008	0.028	0.005	0.239	14	None	None	None	None	None	None
......	B	" "	0.018	0.046	0.007	0.019	0.004	0.299	13	None	None	None	None	None	None
Co...	B	" "	0.08	0.40	0.092	0.037	0.004	0.153	1	None	None	None	None	None	None
Co...	B	" "	0.09	0.31	0.088	0.047	.....	0.271	3	None	None	None	None	None	None
Co...	B	" "	0.07	0.36	0.085	0.033	.....	0.549	3	None	None	None	None	None	None
be Co.	B	" "	0.06	0.37	0.054	0.064	.....	0.223	3	None	None	None	None	None	None
be Co.	B	" "	0.09	0.33	0.032	0.056	0.003	0.575	3	None	None	None	None	None	None
be Co.	B	" "	0.07	0.40	0.056	0.048	.....	0.364	2	None	None	None	None	None	None
......	A	Non-Copper-bearing	0.043	0.419	0.083	0.042	0.004	0.012	17	None	None	None	25, 26, 27, 28, 29 30, 50, 51, 52, 53 54, 55, 56 (**13**)	21, 22, 23, 24 (**4**)	
......	A	" " "	0.056	0.349	0.022	0.048	0.037	0.113	17	None	None	None	None	None	None
......	A	" " "	0.019	0.029	0.004	0.032	0.003	0.067	12	None	None	None	None	None	None
......	A	" " "	0.019	0.028	0.004	0.027	0.004	0.028	18	None	None	None	None	None	None
......	A	" " "	0.108	0.371	0.009	0.029	0.007	0.029	12	None	None	None	None	None	None
......	B	" " "	0.107	0.414	0.010	0.029	0.007	0.057	14	None	None	None	None	None	None
......	B	" " "	0.017	0.021	0.006	0.021	0.006	0.025	14	None	None	None	None	None	29, 30, 31, 32, 33 35, 39, 40 (**8**)
......	B	" " "	0.021	0.062	0.008	0.030	0.005	0.028	14	None	None	None	None	None	29, 30, 31 32, 41 (**5**)
......	B	" " "	0.03	0.051	0.123	0.019	0.203	0.023	3	None	None	None	None	None	None
......	B	" " "	0.07	0.40	0.097	0.037	0.008	0.013	3	None	None	None	None	8, 10, 14 (**3**)	
......	B	" " "	0.032	0.40	0.044	0.028	.....	0.028	2	None	None	None	None	None	None

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been considered as non-copper bearing, and those above 0.15 per cent as copper-bearing.

9, inspection, but are placed in this column because they were exposed about six months later than all other sheets.

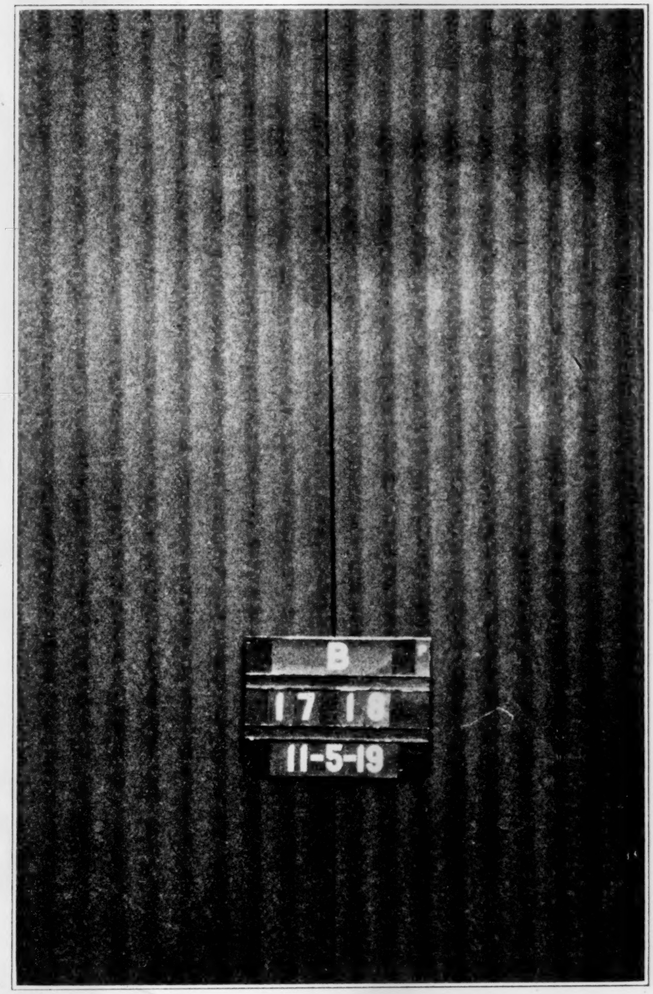

Fig. 1.—Pittsburgh Tests.

No. 22 Gage Open-Hearth Steel—Series A.

Sheet.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
B 17........	0.06	0.24	0.010	0.065	0.003	0.169	....
B 18........	0.04	0.24	0.021	0.063	0.003	0.178	....

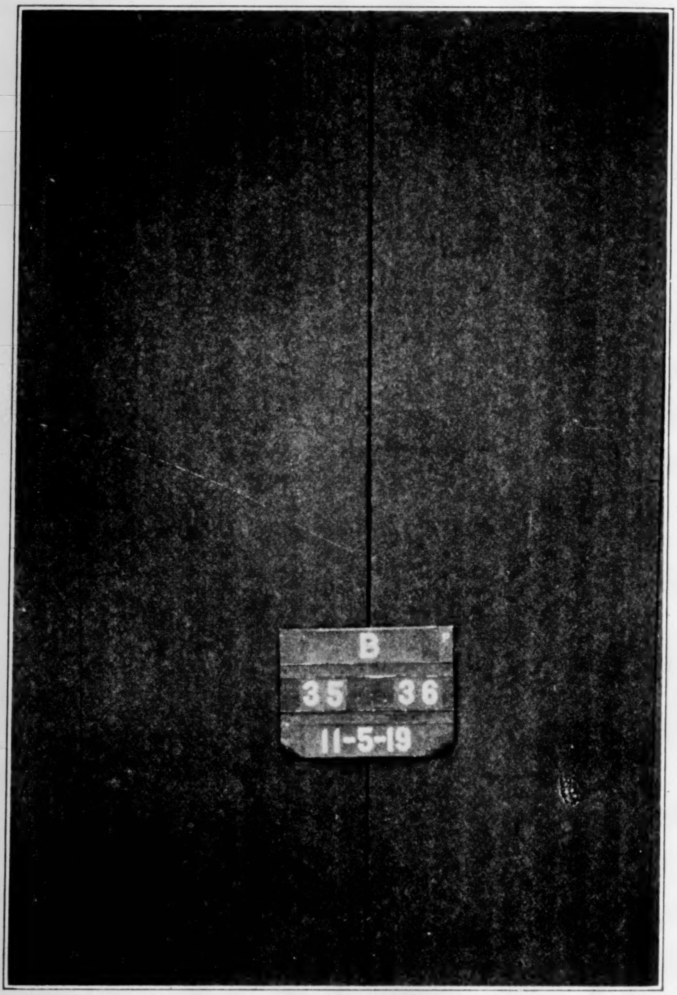

FIG. 2.—PITTSBURGH TESTS.

NO. 22 GAGE OPEN-HEARTH STEEL—SERIES A.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
B 35........	0.10	0.40	0.017	0.077	0.042	0.090	0.055
B 36........	0.10	0.40	0.017	0.077	0.014	0.078	0.055

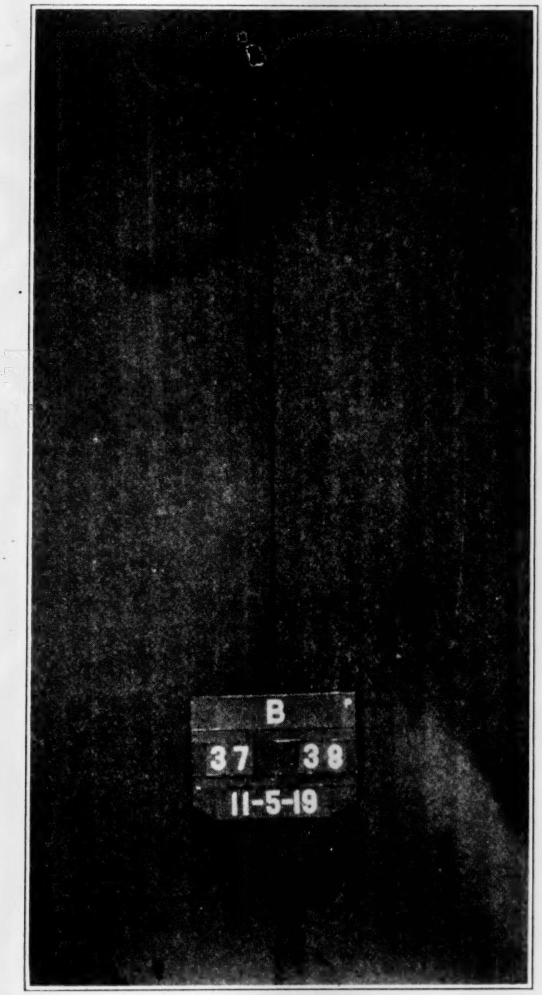

FIG. 3.—PITTSBURGH TESTS.

NO. 22 GAGE OPEN-HEARTH STEEL—SERIES A.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
B 37........	0.08	0.37	0.020	0.046	0.056	0.080	0.055
B 38........	0.06	0.36	0.015	0.047	0.033	0.078	0.050

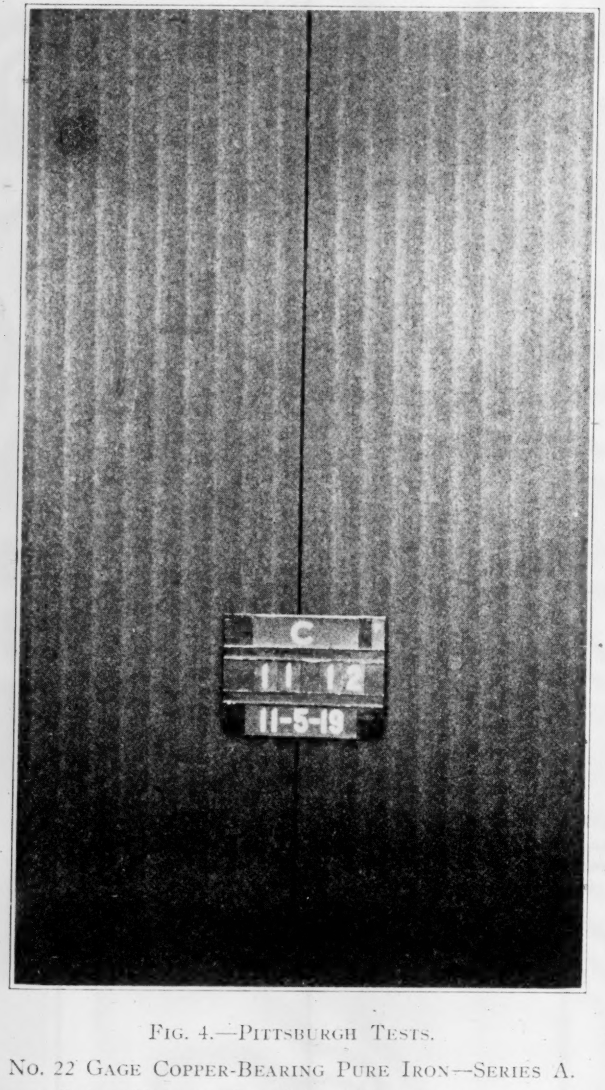

FIG. 4.—PITTSBURGH TESTS.

NO. 22 GAGE COPPER-BEARING PURE IRON—SERIES A.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel. per cent.
C 11........	0.019	0.035	0.009	0.040	0.004	0.189	....
C 12........	0.036	0.038	0.010	0.043	0.002	0.209	....

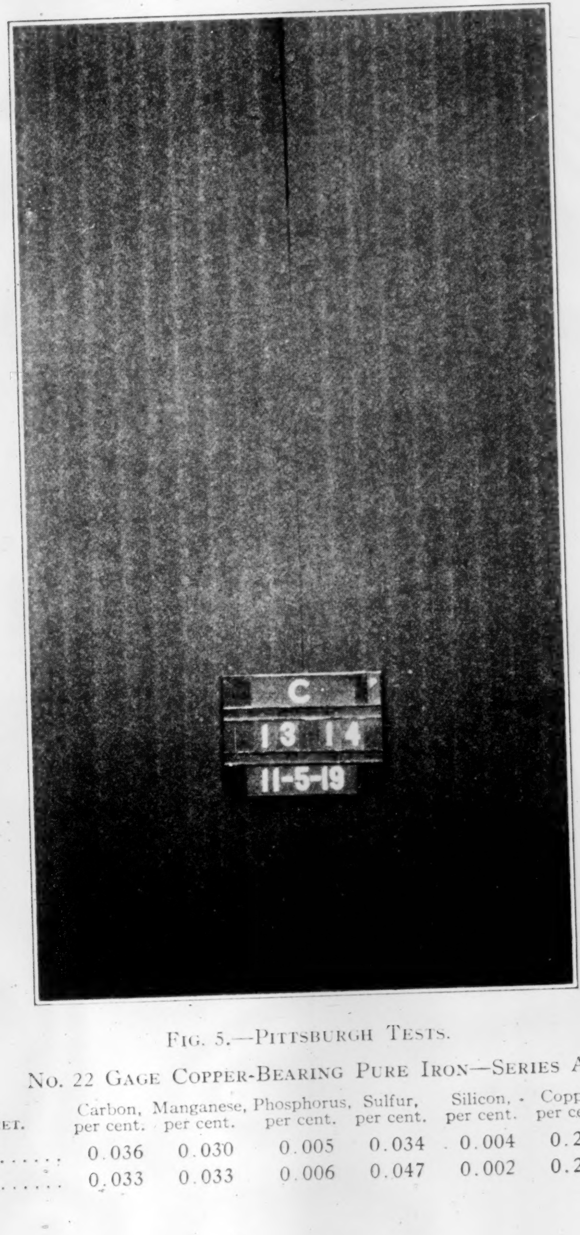

Fig. 5.—Pittsburgh Tests.

No. 22 Gage Copper-Bearing Pure Iron—Series A.

Sheet.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
C 13........	0.036	0.030	0.005	0.034	0.004	0.214	....
C 14........	0.033	0.033	0.006	0.047	0.002	0.230	....

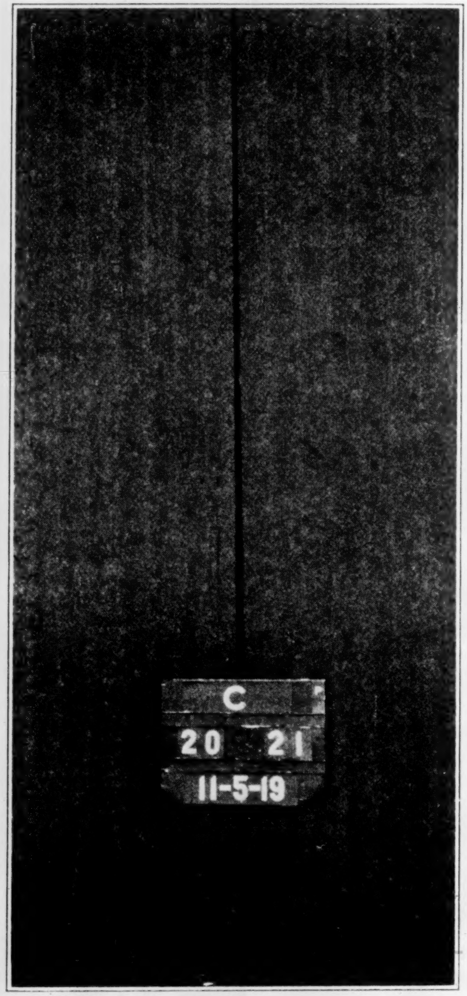

FIG. 6.—PITTSBURGH TESTS.

NO. 22 GAGE COPPER-BEARING PURE IRON—SERIES A.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
C 20........	0.01	0.028	0.001	0.027	0.002	0.140	0.024
C 21........	0.01	0.028	0.002	0.027	0.002	0.137	0.048

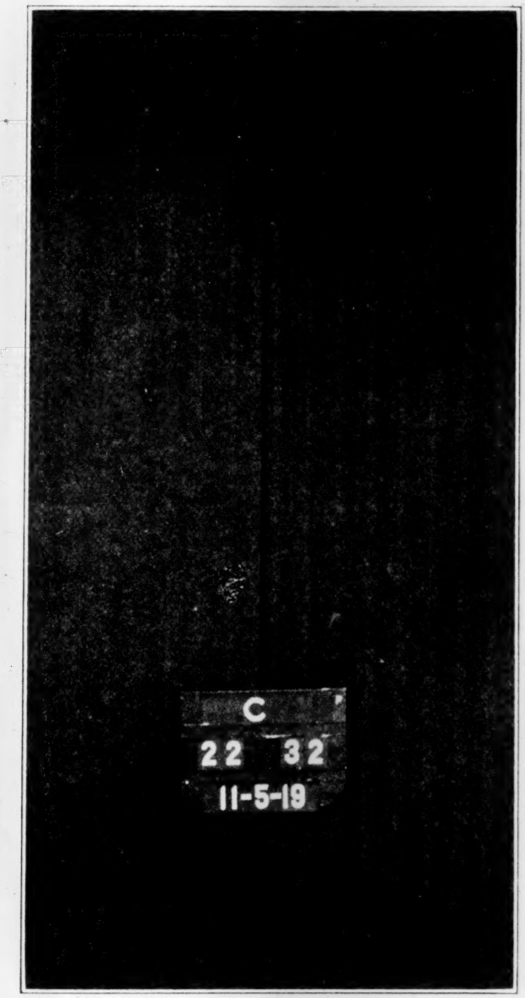

FIG. 7.—PITTSBURGH TESTS.

NO. 22 GAGE COPPER-BEARING PURE IRON—SERIES A.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent
C 22........	0.06	0.04	0.005	0.034	0.004	0.19	0.015
C 32........	0.02	0.02	0.005	0.027	0.009	0.17	....

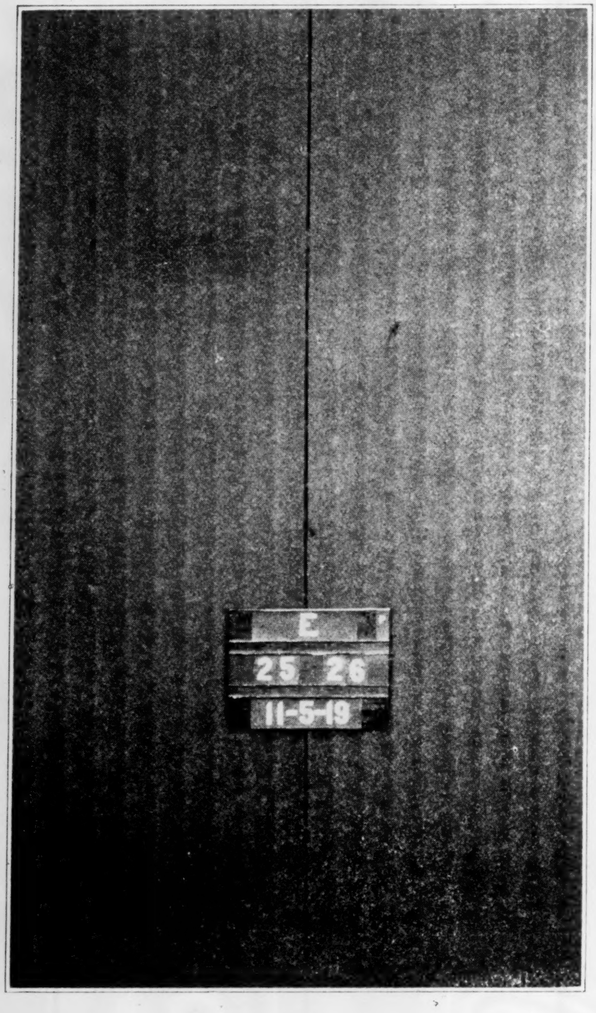

FIG. 8.—PITTSBURGH TESTS.

NO. 22 GAGE PUDDLED IRON—SERIES A.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
E 25........	0.04	0.05	0.101	0.019	0.11	0.31	0.03
E 26........	0.05	0.07	0.127	0.020	0.15	0.32	0.03

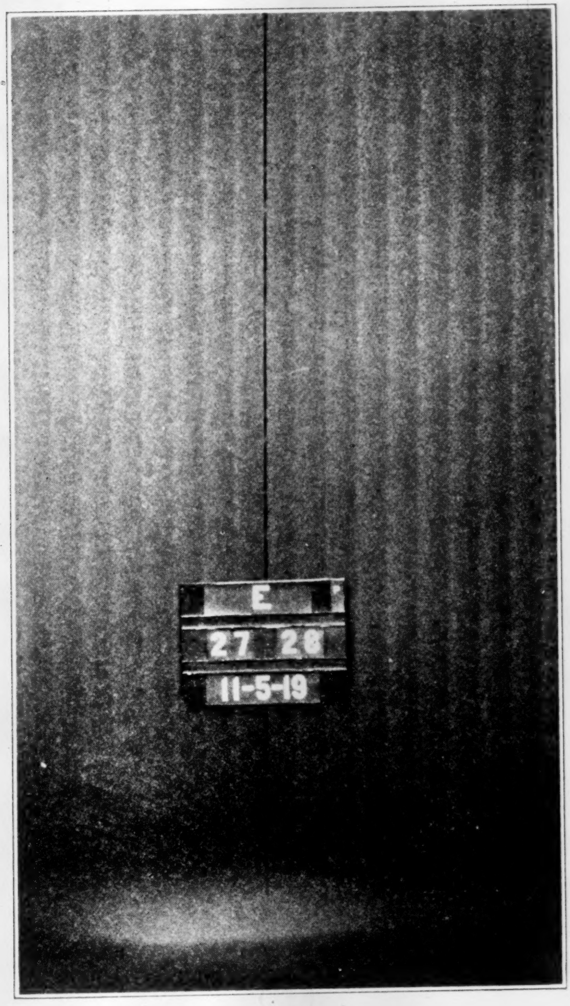

Fig. 9.—Pittsburgh Tests.

No. 22 Gage Puddled Iron—Series A.

Sheet.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
E 27........	0.02	0.06	0.120	0.021	0.14	0.32	0.04
E 28........	0.03	0.06	0.124	0.023	0.14	0.31	0.03

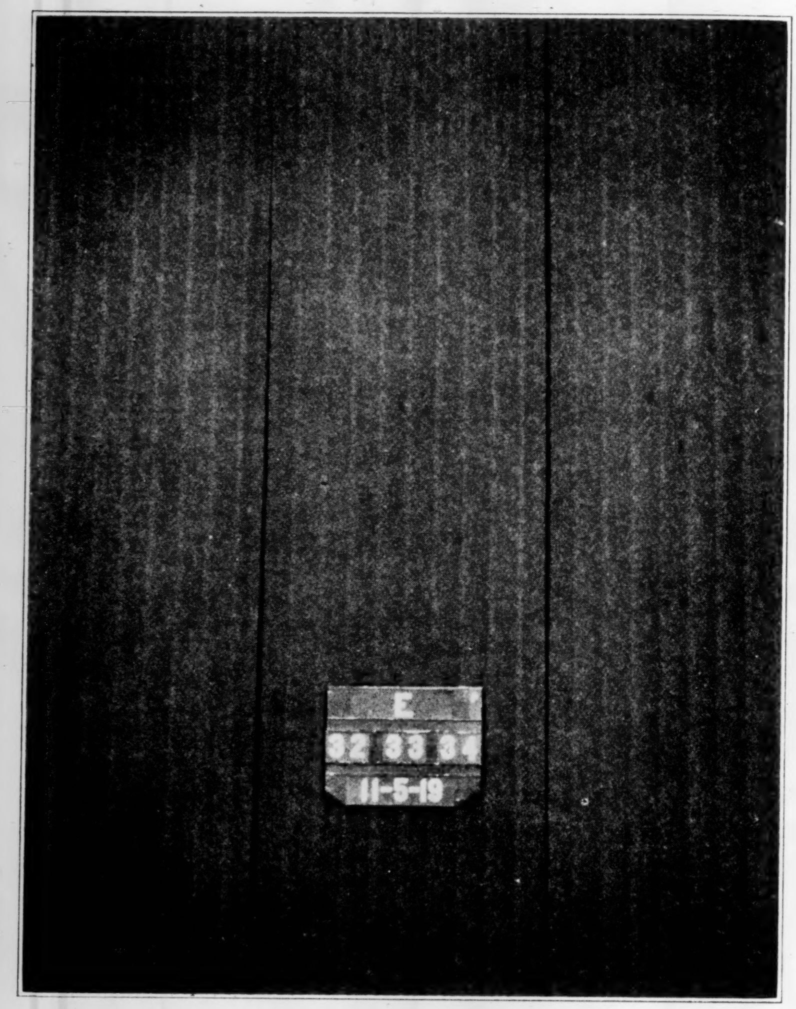

FIG. 10.—PITTSBURGH TESTS.

NO. 22 GAGE PUDDLED IRON—SERIES A.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
E 32........	0.02	0.02	0.111	0.021	0.141	0.31	0.020
E 33........	0.05	0.02	0.113	0.019	0.125	0.29	0.025
E 34........	0.04	0.02	0.123	0.021	0.141	0.29	0.020

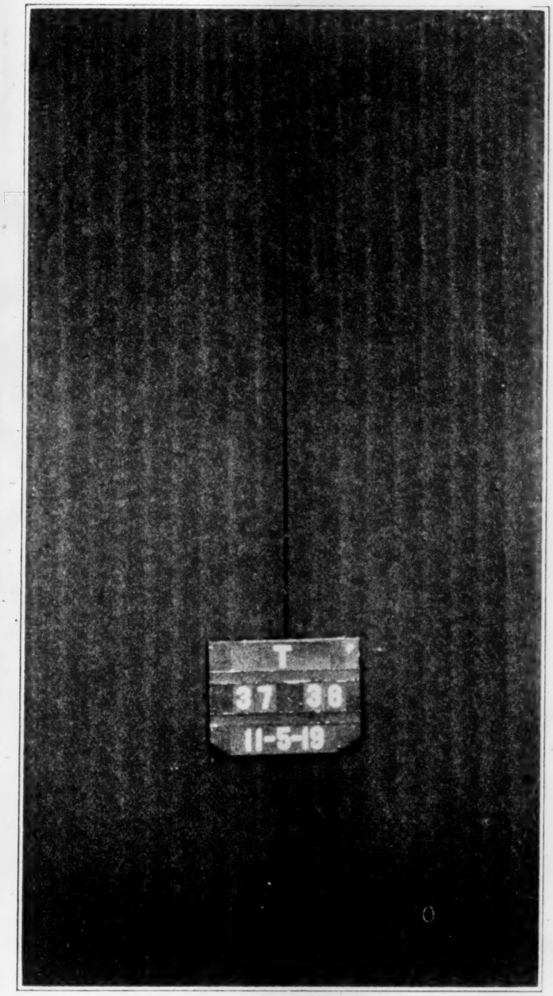

FIG. 11.—PITTSBURGH TESTS.

NO. 22 GAGE COPPER-BEARING OPEN-HEARTH STEEL—SERIES B.

Newport Rolling Mill Co.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
T 37........	0.07	0.30	0.009	0.021	Trace	0.23	None
T 38........	0.07	0.32	0.010	0.024	Trace	0.21	None

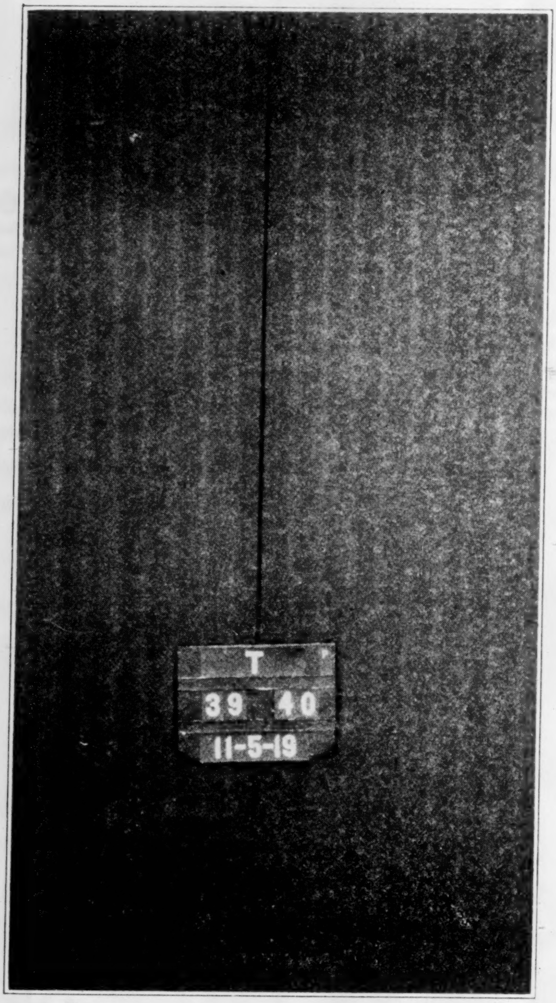

FIG. 12.—PITTSBURGH TESTS.

NO. 22 GAGE COPPER-BEARING OPEN-HEARTH STEEL—SERIES B.

Newport Rolling Mill Co.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
T 39........	0.075	0.32	0.008	0.024	Trace	0.19	None
T 40........	0.085	0.31	0.009	0.025	Trace	0.20	None

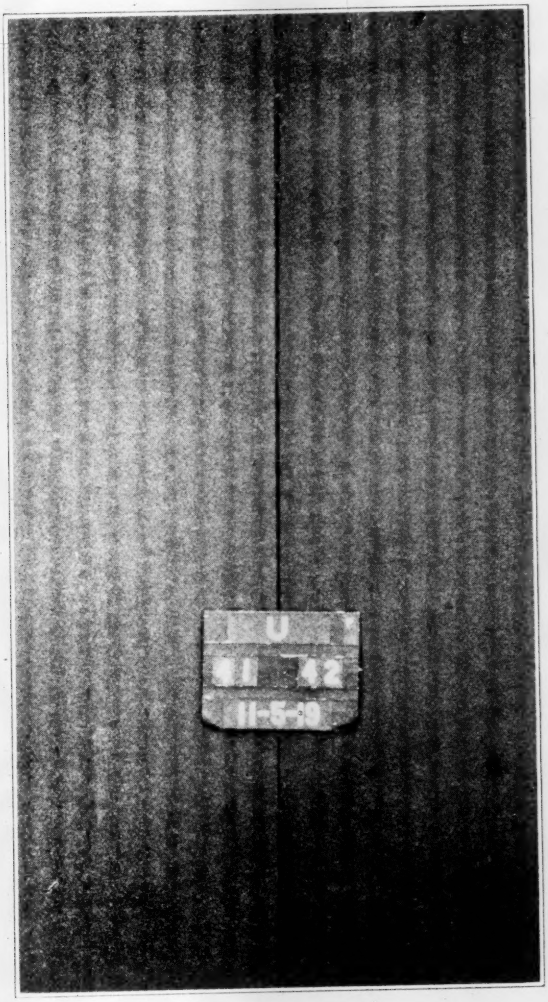

FIG. 13.—PITTSBURGH TESTS.

NO. 22 GAGE COPPER-BEARING PURE IRON—SERIES B.

Allegheny Steel Co.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
U 41........	0.005	0.07	0.008	0.037	Trace	0.28	None
U 42........	0.01	0.07	0.008	0.036	Trace	0.28	None

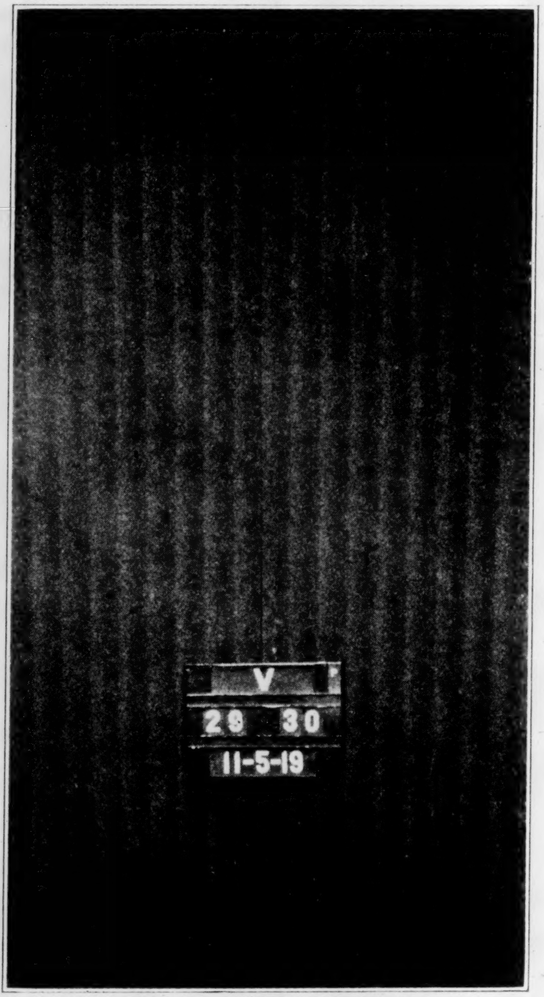

FIG. 14.—PITTSBURGH TESTS.

NO. 22 GAGE COPPER-BEARING PURE IRON—SERIES B.

Whitaker-Glessner Co.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
V 29........	0.021	0.036	0.006	0.017	....	0.312	None
V 30........	0.02	0.036	0.005	0.016	....	0.296	None

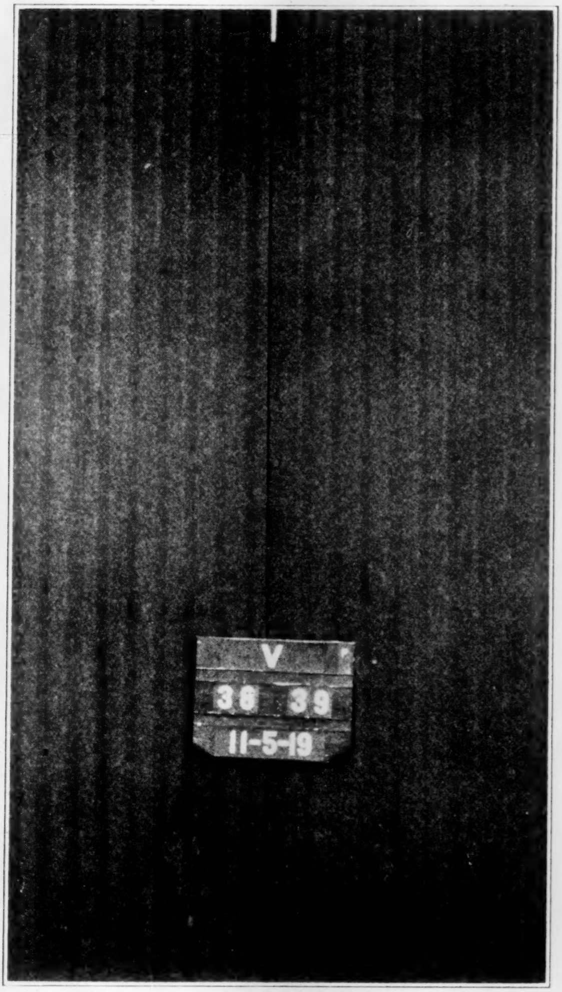

FIG. 15.—PITTSBURGH TESTS.

NO. 22 GAGE COPPER-BEARING PURE IRON—SERIES B.

Whitaker-Glessner Co.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
V 38........	0.025	0.05	0.007	0.024	Trace	0.31	None
V 39........	0.01	0.05	0.006	0.024	Trace	0.31	None

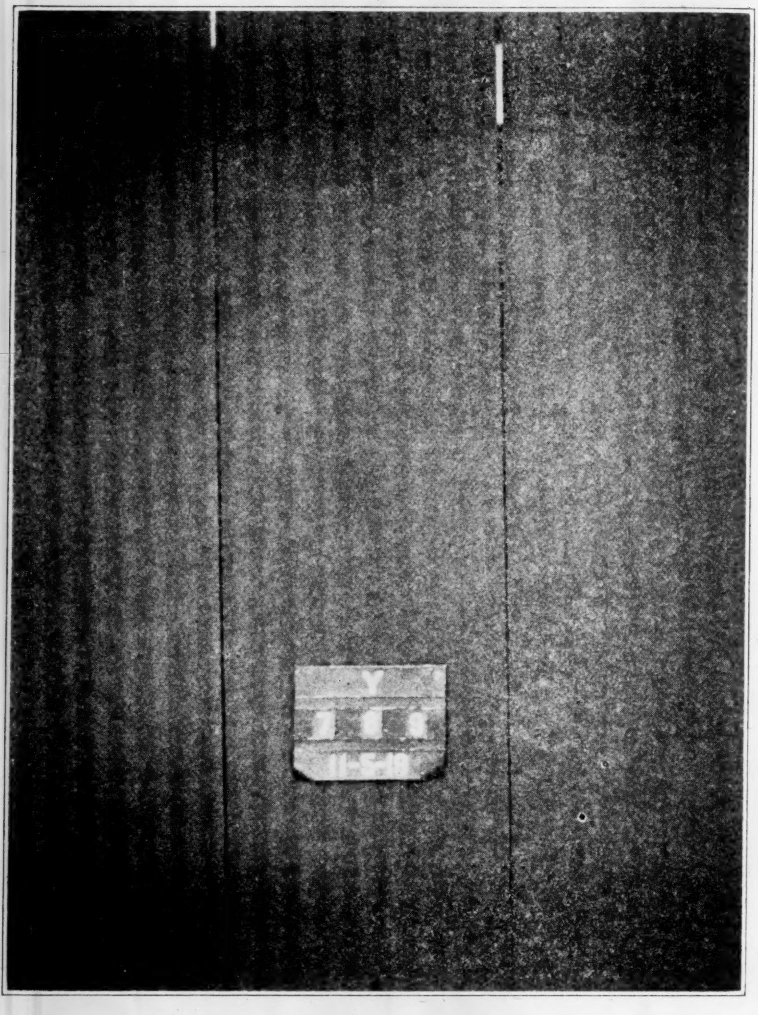

FIG. 16.—PITTSBURGH TESTS.

NO. 22 GAGE LOW-COPPER WROUGHT IRON—SERIES B.

Youngstown Sheet and Tube Co.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
Y 7	0.03	0.06	0.153	0.021	0.20	0.020	....
Y 8	0.03	0.06	0.155	0.019	0.23	0.024	....
Y 9	0.03	0.07	0.160	0.021	0.25	0.024	....

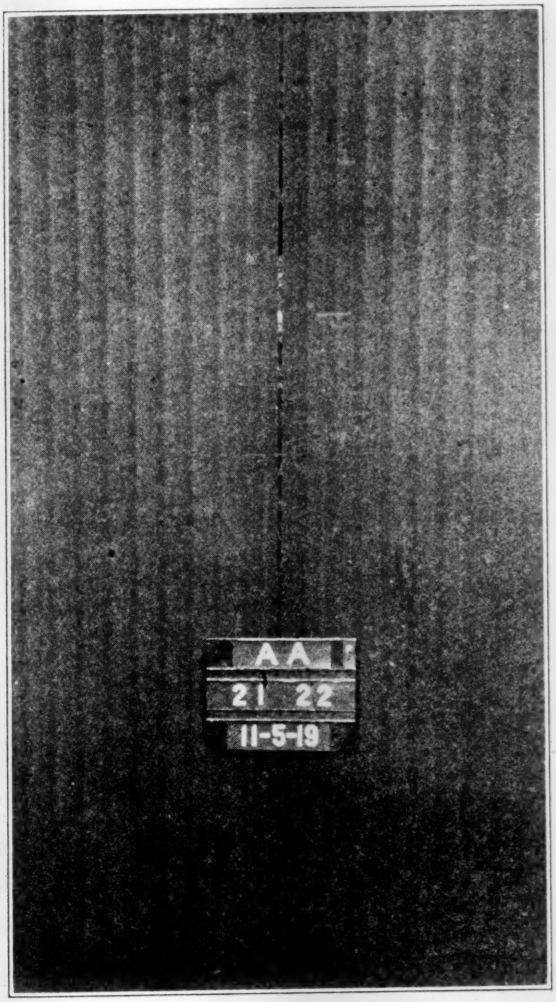

FIG. 17.—PITTSBURGH TESTS.

NO. 16 GAGE BESSEMER STEEL—SERIES A.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
AA 21.......	0.018	0.40	0.085	0.043	0.004	0.010	....
AA 22.......	0.022	0.42	0.085	0.041	0.002	0.010	....

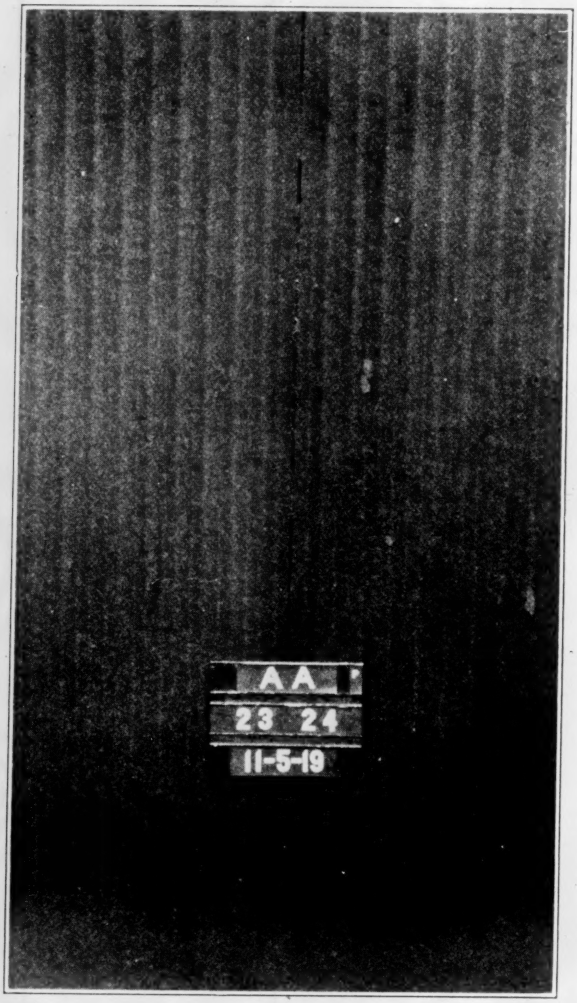

FIG. 18.—PITTSBURGH TESTS.

NO. 16 GAGE BESSEMER STEEL—SERIES A.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent
AA 23.......	0.034	0.42	0.084	0.041	0.004	0.010	....
AA 24.......	0.018	0.41	0.086	0.041	0.002	0.010	....

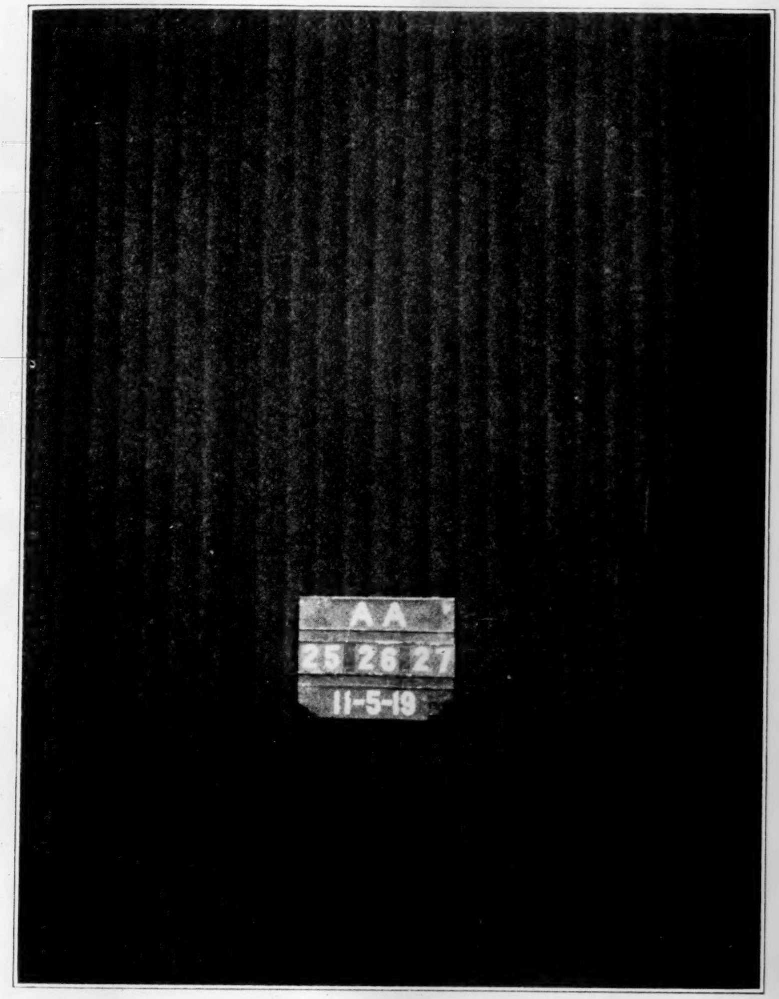

FIG. 19.—PITTSBURGH TESTS.

NO. 16 GAGE BESSEMER STEEL—SERIES A.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
AA 25.......	0.032	0.40	0.087	0.039	....	0.019	....
AA 26.......	0.032	0.40	0.083	0.037	....	0.018	....
AA 27.......	0.032	0.39	0.085	0.041	....	0.018	....

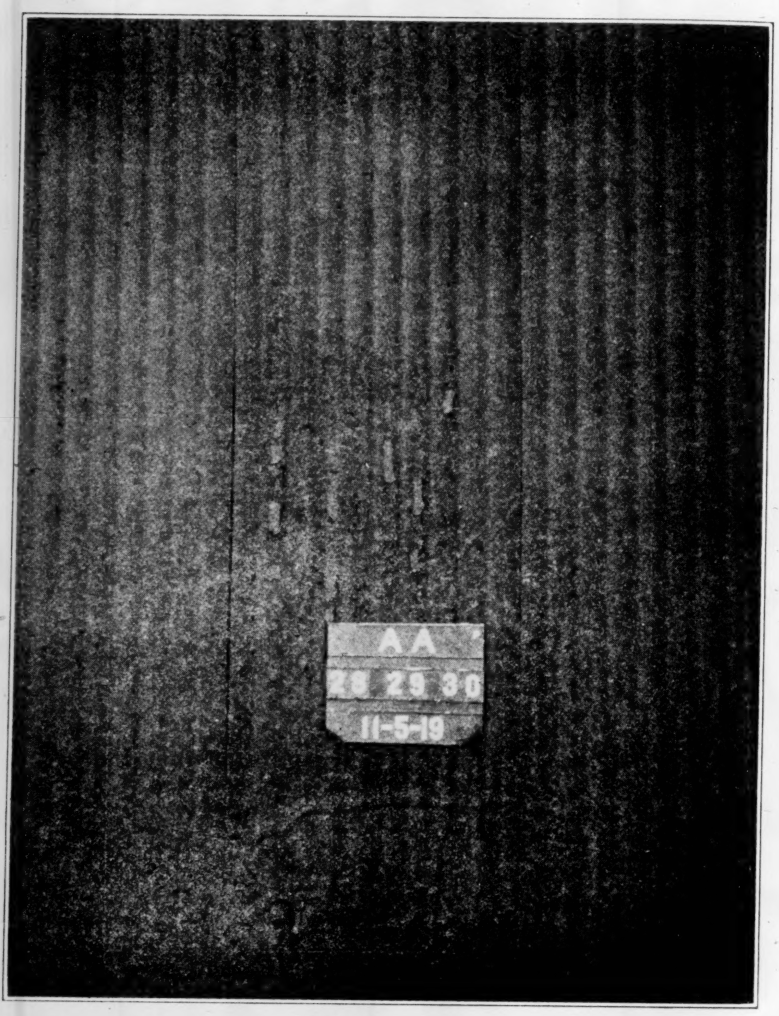

FIG. 20.—PITTSBURGH TESTS.

NO. 16 GAGE BESSEMER STEEL—SERIES A.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
AA 28.......	0.035	0.40	0.080	0.039	....	0.018	....
AA 29.......	0.035	0.40	0.086	0.040	....	0.016	....
AA 30.......	0.035	0.39	0.082	0.040	....	0.018	....

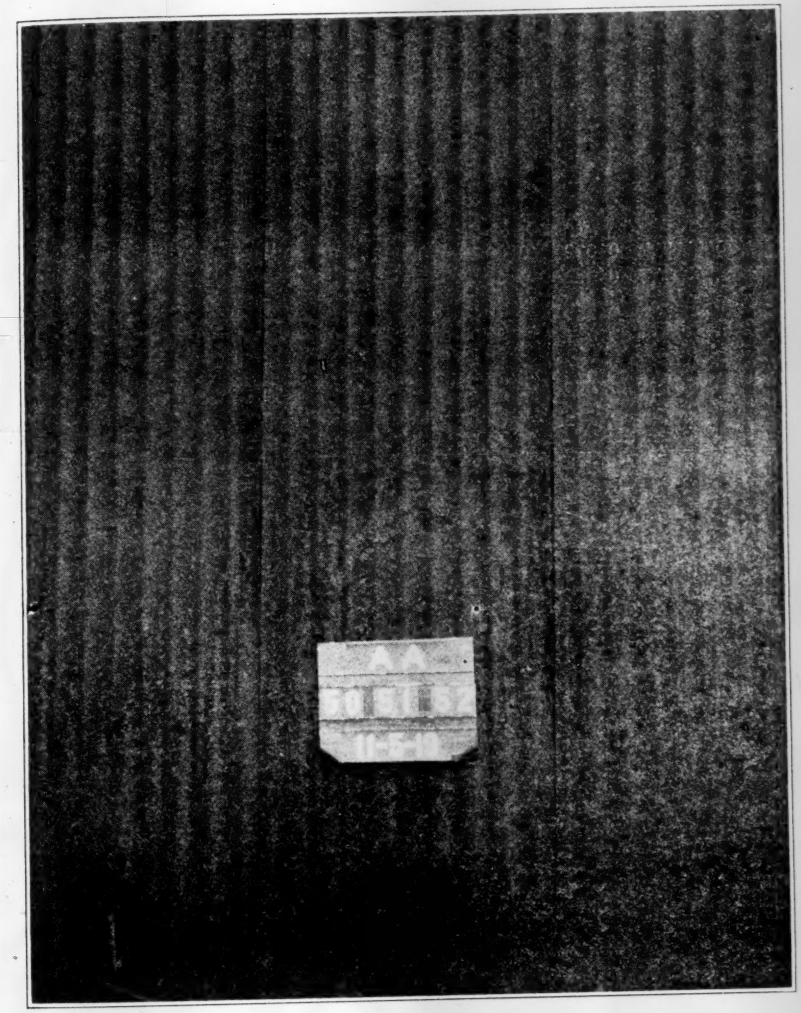

FIG. 21.—PITTSBURGH TESTS.

NO. 16 GAGE BESSEMER STEEL—SERIES A.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
AA 50........	0.08	0.42	0.093	0.046	....	0.006	....
AA 51........	0.07	0.44	0.085	0.041	0.009	0.008	0.002
AA 52........	0.05	0.44	0.086	0.041	....	0.012	....

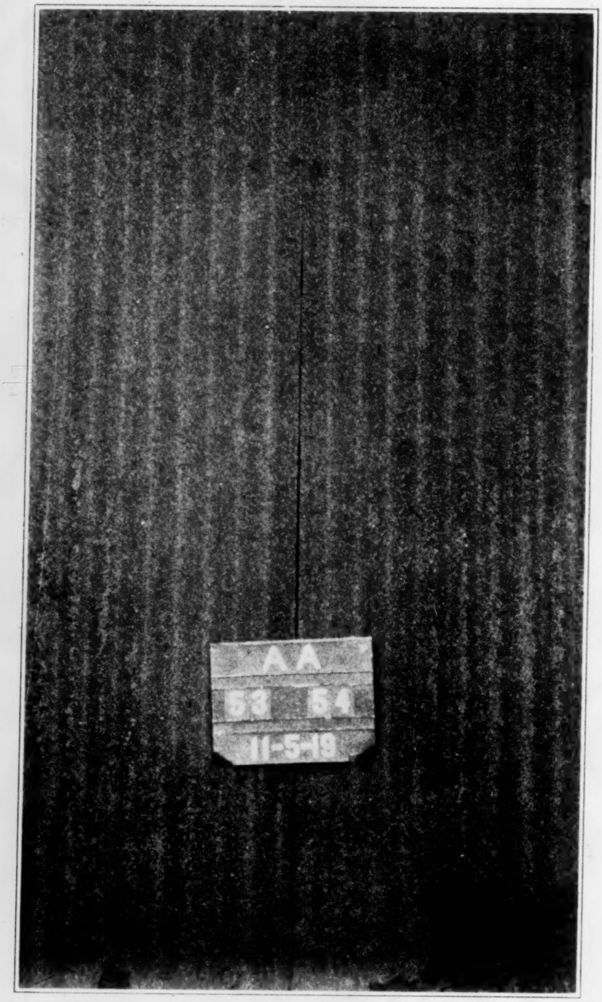

FIG. 22.—PITTSBURGH TESTS.

NO. 16 GAGE BESSEMER STEEL—SERIES A.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
AA 53......	0.06	0.42	0.083	0.045	....	0.008	....
AA 54......	0.05	0.42	0.089	0.041	....	0.006	....

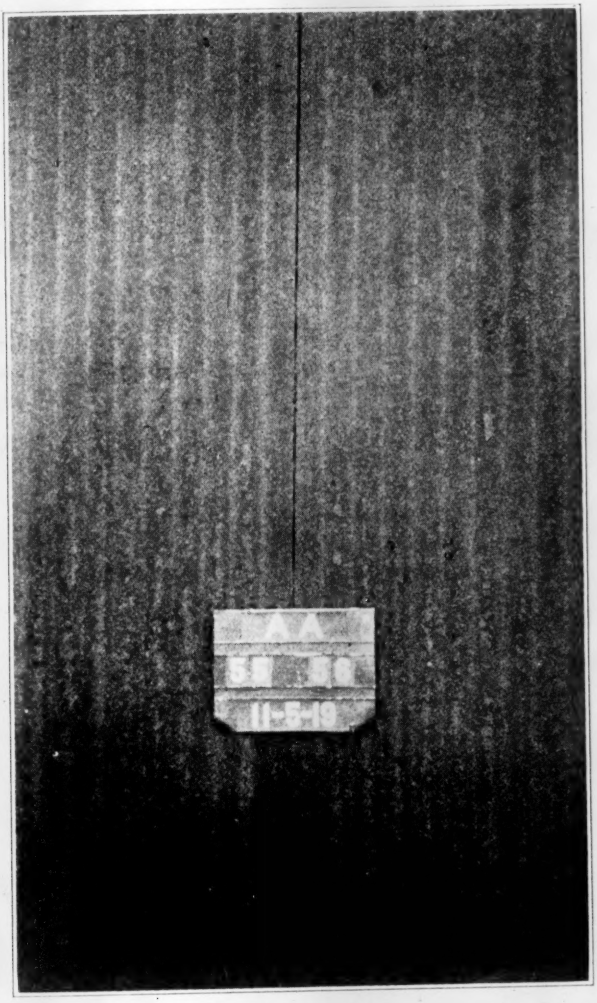

Fig. 23.—Pittsburgh Tests.

No. 16 Gage Bessemer Steel—Series A.

Sheet.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
AA 55.......	0.05	0.41	0.088	0.041	....	0.006	....
AA 56.......	0.05	0.42	0.091	0.045	0.009	0.004	....

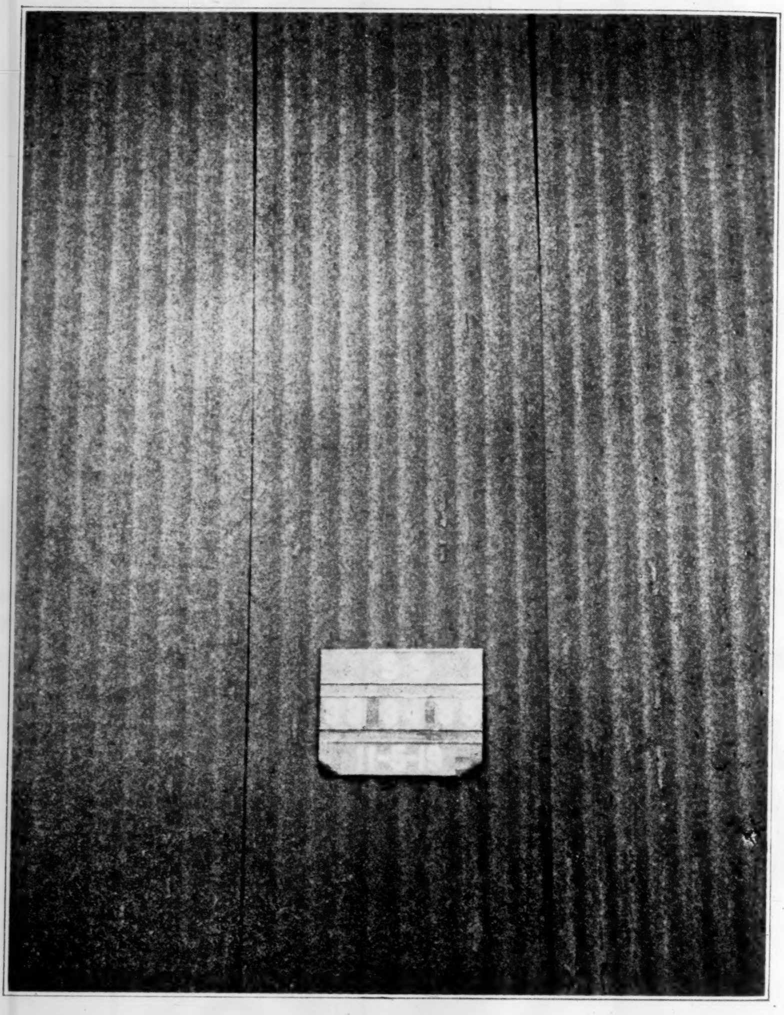

FIG. 24.—PITTSBURGH TESTS.

NO. 16 GAGE LOW-COPPER PURE IRON—SERIES B.
American Rolling Mill Co.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
SS 33	0.02	0.018	0.003	0.029	....	0.027	None
SS 34	0.02	0.018	0.004	0.023	0.002	0.020	None
SS 35	0.02	0.02	0.007	0.028	....	0.03	None

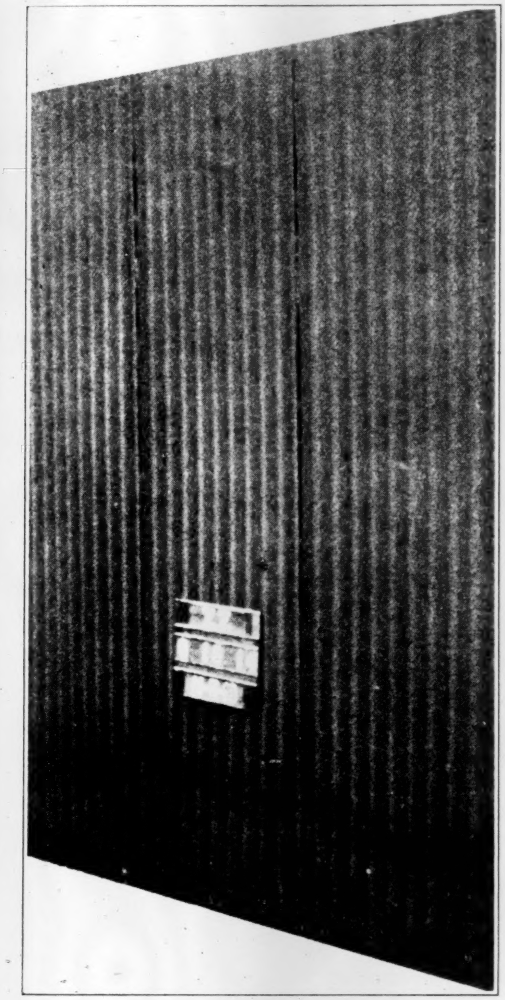

FIG. 25.—PITTSBURGH TESTS.

NO. 16 GAGE BESSEMER STEEL, WITH VARYING COPPER CONTENT—SERIES B
Youngstown Sheet and Tube Co.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
ZZ 8.......	0.08	0.41	0.110	0.045	....	0.014	None
ZZ 10.......	0.07	0.46	0.106	0.040	0.008	0.014	None
ZZ 14.......	0.07	0.33	0.074	0.026	....	0.010	None

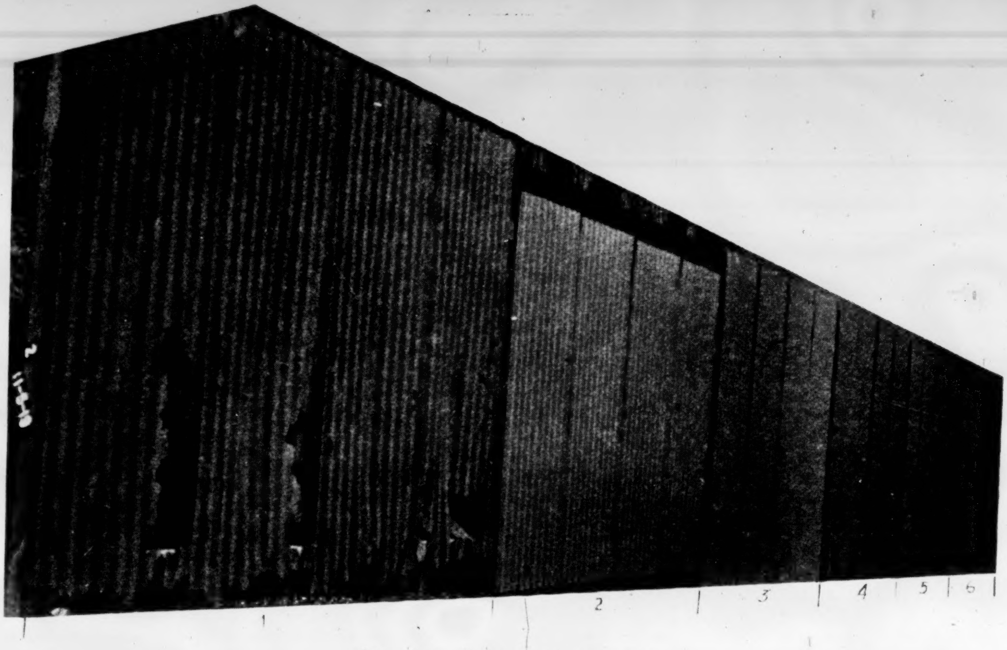

FIG. 26.—PITTSBURGH TESTS.

End View—Row No. 2.

1. A 31, 32, 33, 34. No. 22 GAGE BESSEMER STEEL—SERIES A.
2. B 17, 18, 19, 20. No. 22 GAGE OPEN-HEARTH STEEL—SERIES A.
3. C 11, 12, 13, 14. No. 22 GAGE COPPER-BEARING PURE IRON—SERIES A.
4. D 30, 31, 33, 34. No. 22 GAGE LOW-COPPER PURE IRON—SERIES A.
5. E 25, 26, 27, 28. No. 22 GAGE PUDDLED IRON—SERIES A.
6. H 38, 40, 41, 42. No. 22 GAGE COPPER-BEARING BASIC OPEN-HEARTH STEEL—SERIES A.

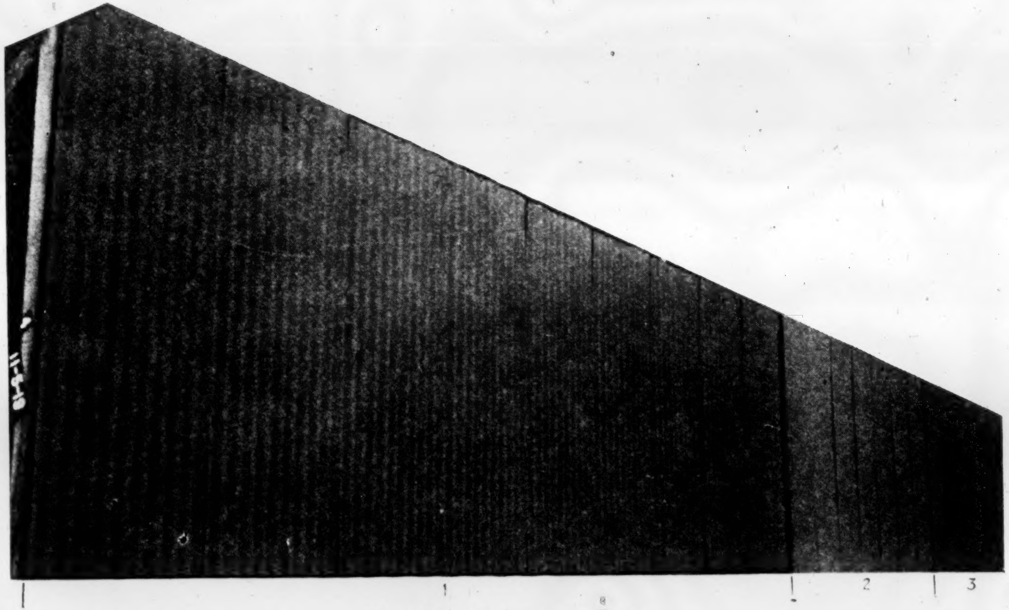

Fig. 27.—Pittsburgh Tests.

End View—Row No. 4.

1. II[1] 48 to 56 incl. No. 16 Gage Copper-Bearing Bessemer Steel—Series A.
2. KK 28 to 34 incl. No. 16 Gage Copper-Bearing Acid Open-Hearth Steel—Series A.
3. KK[1] 51 to 58 incl. No. 16 Gage Copper-Bearing Acid Open-Hearth Steel—Series A.

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[1] Sand Blasted.

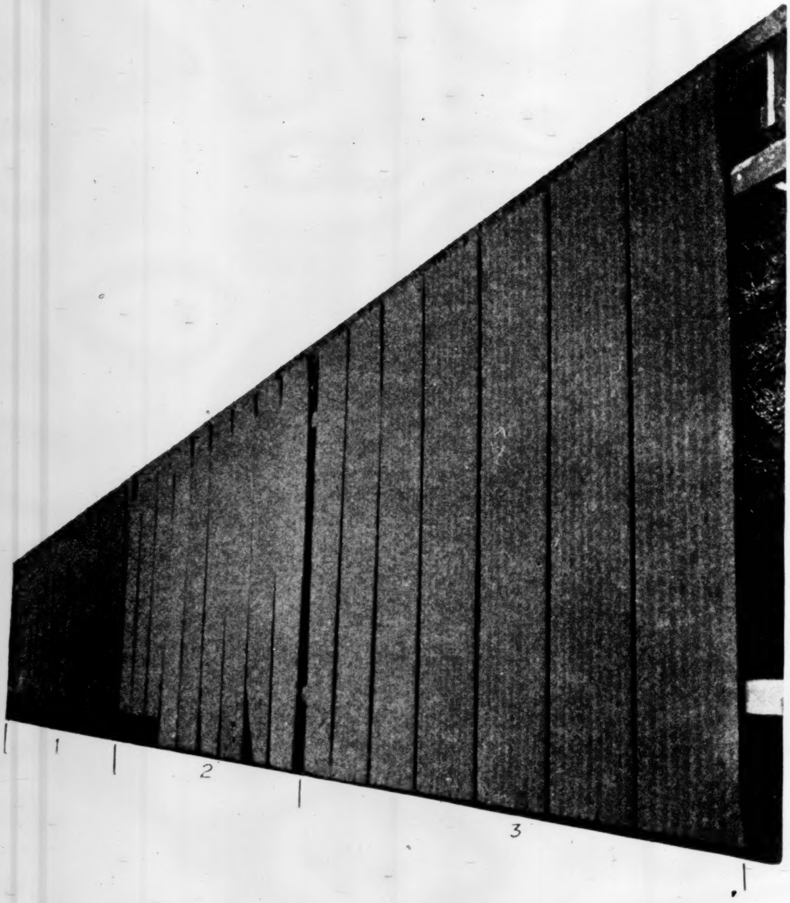


Fig. 28.—Pittsburgh Tests.

End View—Row No. 5.

1.	A 35 to 47 incl.	No. 22 Gage Bessemer Steel—Series A.
2.	B 21, 22, 23, 34 to 39 incl.	No. 22 Gage Open-Hearth Steel—Series A.
3.	C 20, 21, 22, 32 to 35 incl.	No. 22 Gage Copper-Bearing Pure Iron—Series A.

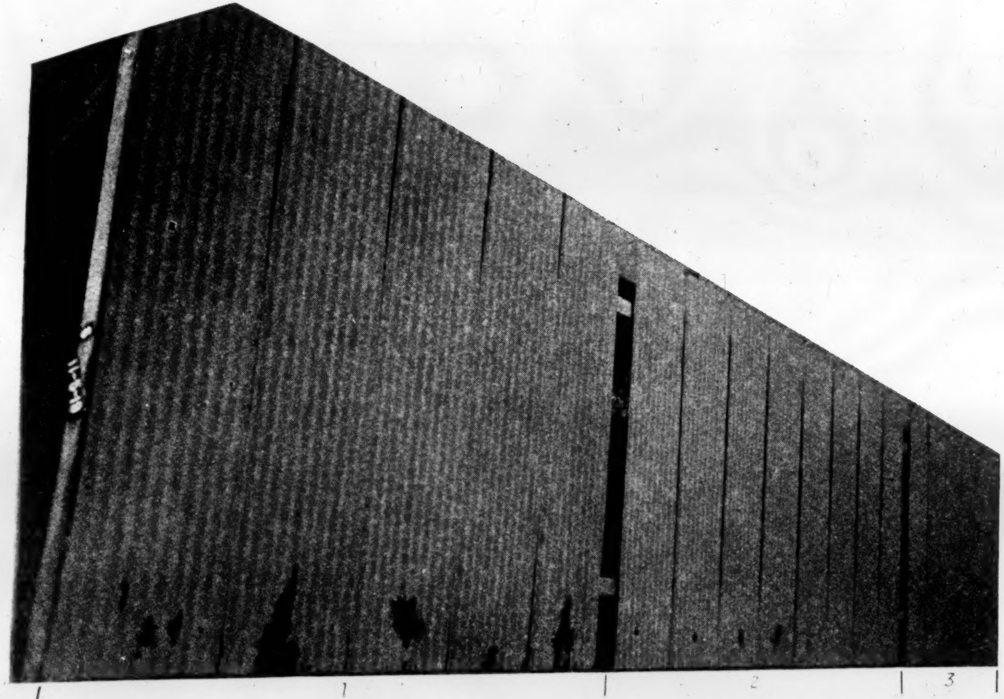


FIG. 29.—PITTSBURGH TESTS.

End View—Row No. 6.

1.	D 35, 36, 38, 39, 40.	NO. 22 GAGE LOW-COPPER PURE IRON SERIES A.
2.	E 29 to 36 incl.	NO. 22 GAGE PUDDLED IRON—SERIES A.
3.	H 43, 45, 47, 49, 50, 53, 54, 55.	NO. 22 GAGE COPPER-BEARING BASIC OPEN-HEARTH STEEL—SERIES A.

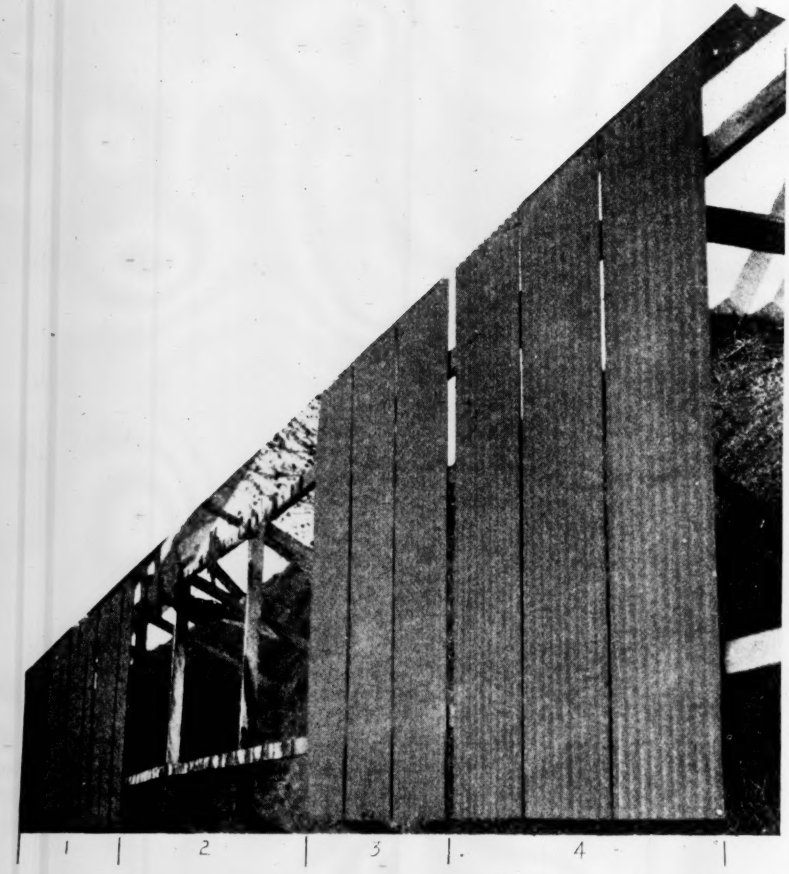


FIG. 30.—PITTSBURGH TESTS.

End View—Row No. 7.

1.	Z 314.	No. 22 GAGE COPPER-BEARING BESSEMER STEEL—SERIES B.
	Z 422, 423, 424.	No. 22 GAGE LOW-COPPER OPEN-HEARTH STEEL—SERIES B.
	Z 509, 513, 516, 607, 608, 609, 712, 714, 715.	No. 22 GAGE COPPER-BEARING OPEN-HEARTH STEEL—SERIES B.
2.	O 29 to 36 incl.	No. 22 GAGE LOW-COPPER OPEN-HEARTH STEEL—SERIES A.
3.	Y 7 to 9 incl.	No. 22 GAGE LOW-COPPER WROUGHT IRON—SERIES B.
4.	YY 7 to 9 incl.	No. 16 GAGE LOW-COPPER WROUGHT IRON—SERIES B.

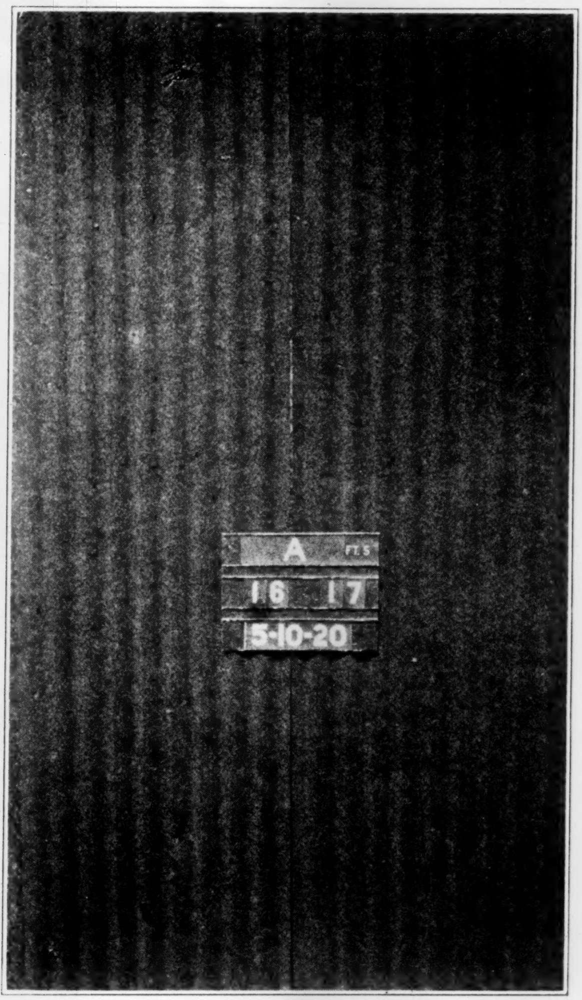


FIG. 31.—FORT SHERIDAN TESTS.

NO. 22 GAGE BESSEMER STEEL—SERIES A.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
A 16........	0.04	0.40	0.096	0.040	....	0.011	....
A 17........	0.04	0.41	0.043	0.040	....	0.011	....

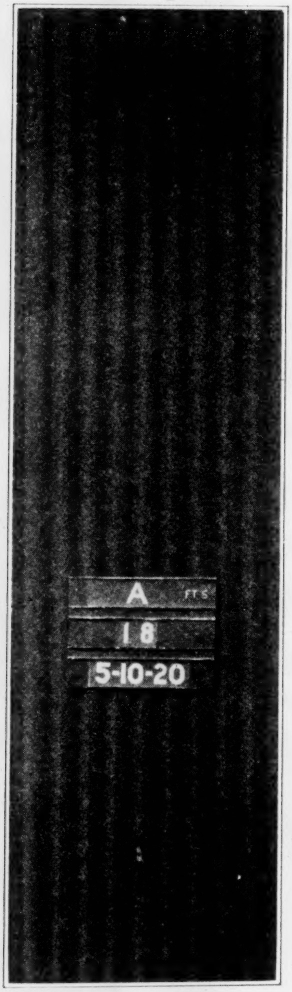


FIG. 32.—FORT SHERIDAN TESTS.

NO. 22 GAGE BESSEMER STEEL—SERIES A.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
A 18........	0.044	0.41	0.103	0.040	....	0.012	....

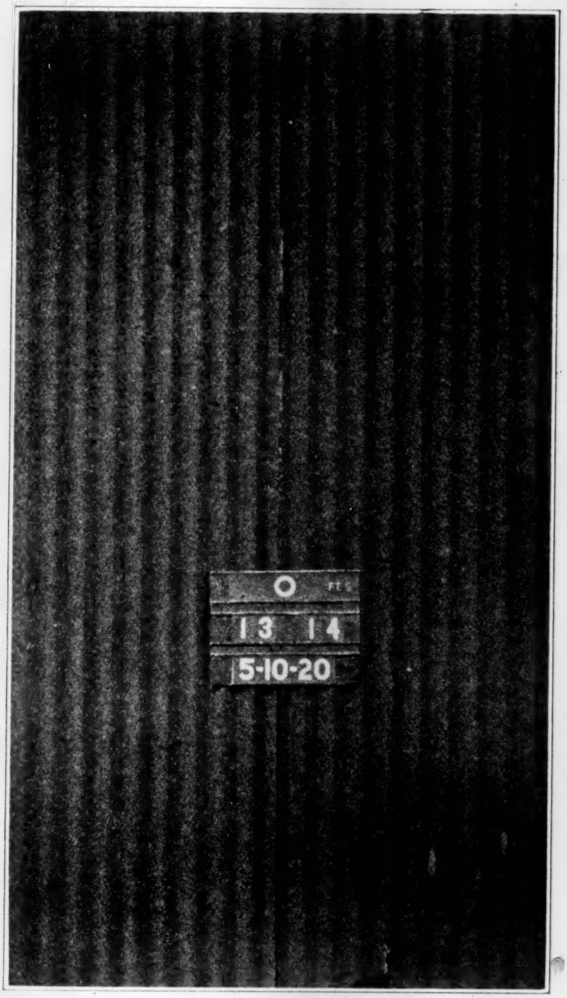


FIG. 33.—FORT SHERIDAN TESTS.

NO. 22 GAGE LOW-COPPER OPEN-HEARTH STEEL—SERIES A.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel per cent.
O 13........	0.11	0.51	0.007	0.033	....	0.032	None
O 14........	0.11	0.51	0.010	0.029	....	0.022	None

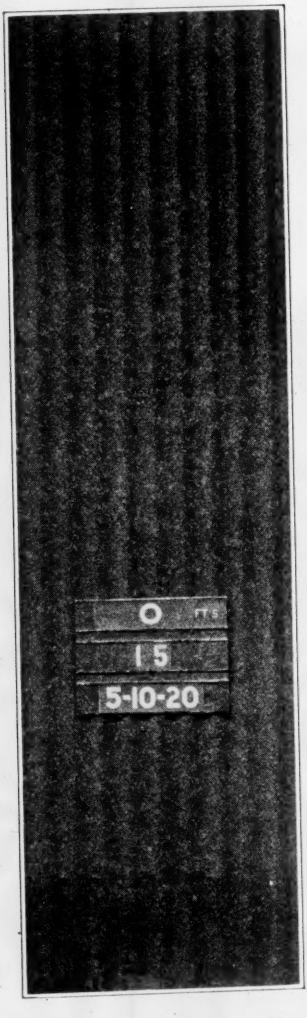


FIG. 34.—FORT SHERIDAN TESTS.

NO. 22 GAGE LOW-COPPER OPEN-HEARTH STEEL—SERIES A.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
O 15........	0.11	0.51	0.009	0.029	0.208	0.024	None

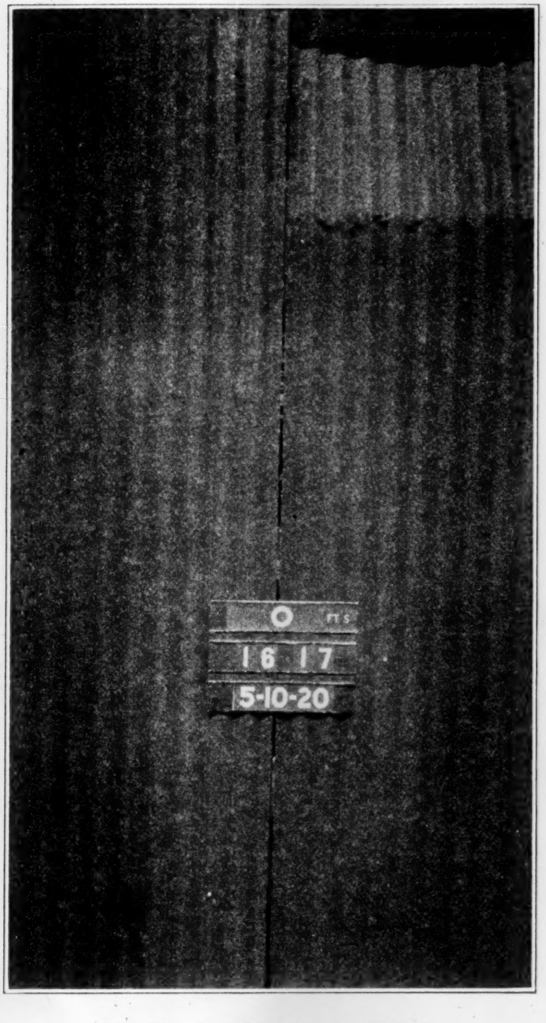


FIG. 35.—FORT SHERIDAN TESTS.

NO. 22 GAGE LOW-COPPER OPEN-HEARTH STEEL—SERIES A.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
O 16........	0.11	0.52	0.008	0.028	....	0.022	None
O 17........	0.11	0.52	0.009	0.029	0.21	0.026	None

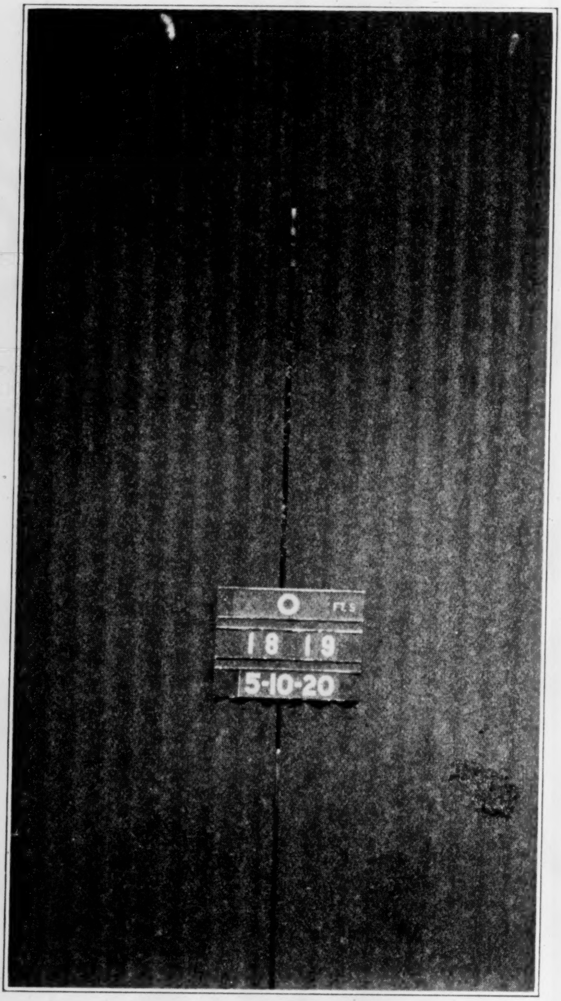


FIG. 36.—FORT SHERIDAN TESTS.

NO. 22 GAGE LOW-COPPER OPEN-HEARTH STEEL—SERIES A.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
O 18........	0.11	0.53	0.005	0.029	....	0.018	None
O 19........	0.11	0.57	0.010	0.035	0.238	0.026	....

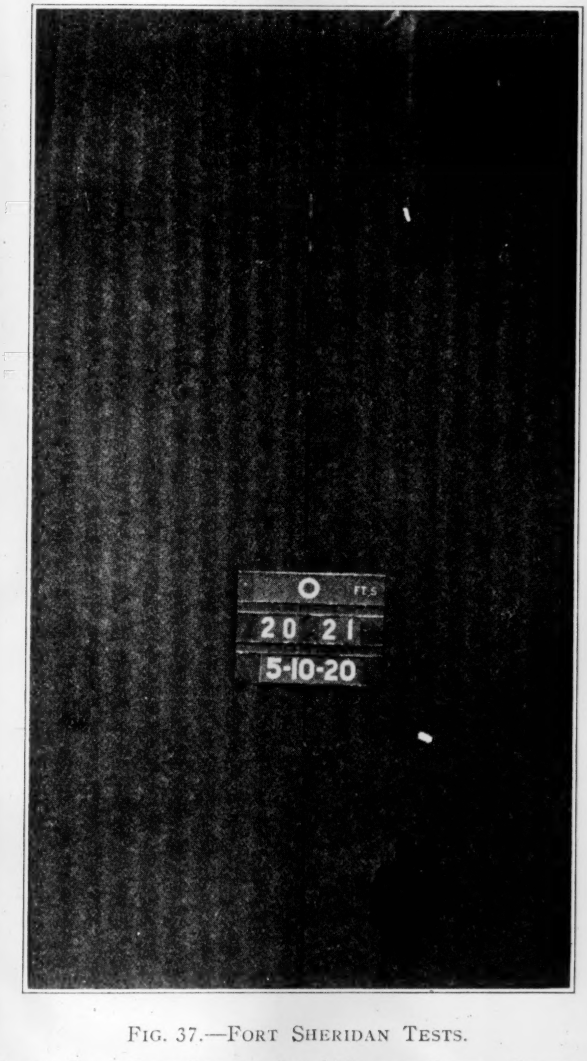


FIG. 37.—FORT SHERIDAN TESTS.

NO. 22 GAGE LOW-COPPER OPEN-HEARTH STEEL—SERIES A.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
O 20........	0.11	0.57	0.008	0.035	0.236	0.026	....
O 21........	0.11	0.57	0.009	0.031	0.236	0.022	....

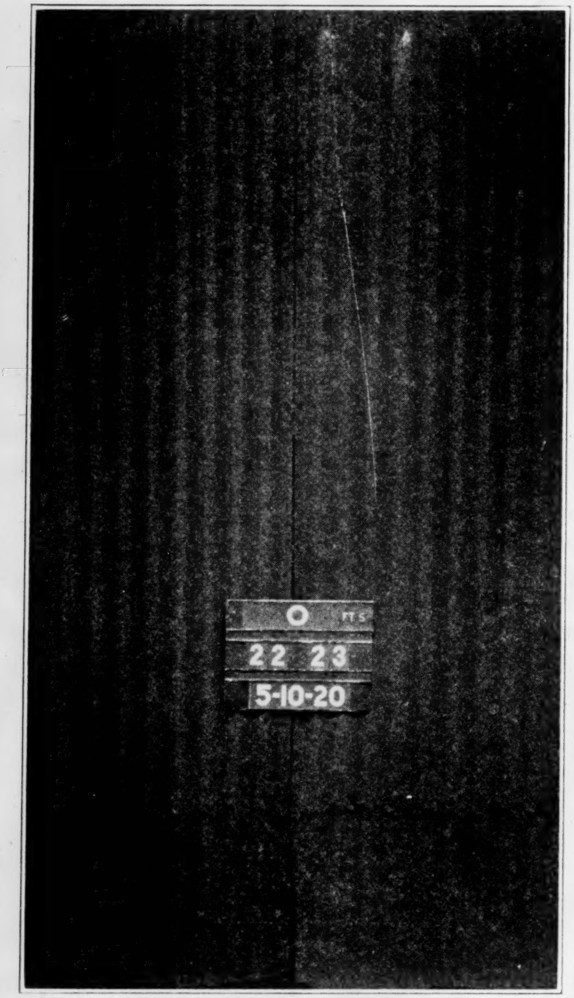


FIG. 38.—FORT SHERIDAN TESTS.

NO. 22 GAGE LOW-COPPER OPEN-HEARTH STEEL—SERIES A.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
O 22........	0.11	0.57	0.010	0.034	0.238	0.026	....
O 23........	0.11	0.57	0.007	0.037	0.229	0.026	....

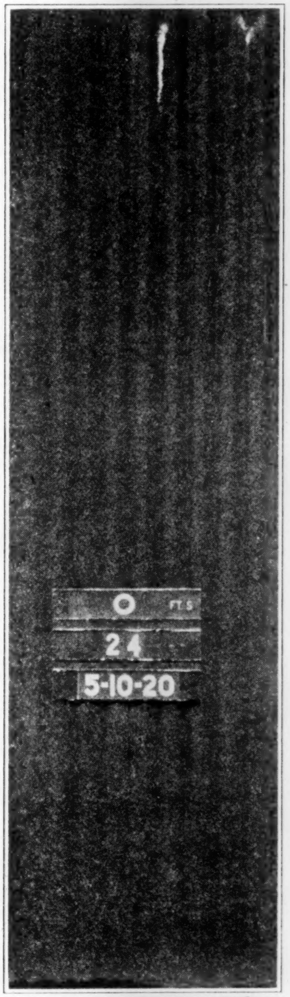


FIG. 39.—FORT SHERIDAN TESTS.

NO. 22 GAGE LOW-COPPER OPEN-HEARTH STEEL—SERIES A.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
O 24........	0.11	0.57	0.010	0.033	0.218	0.022	....

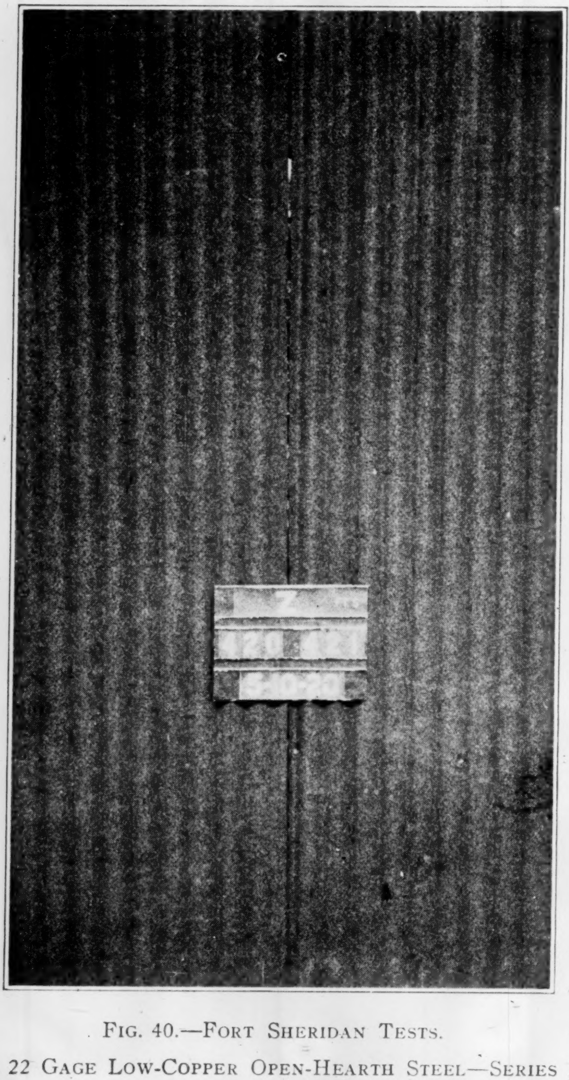


FIG. 40.—FORT SHERIDAN TESTS.

NO. 22 GAGE LOW-COPPER OPEN-HEARTH STEEL—SERIES B.

Youngstown Sheet and Tube Co.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
Z 420.......	0.032	0.33	0.060	0.041	....	0.020	....
Z 421.......	0.092	0.317	0.070	0.044	....	0.024	None

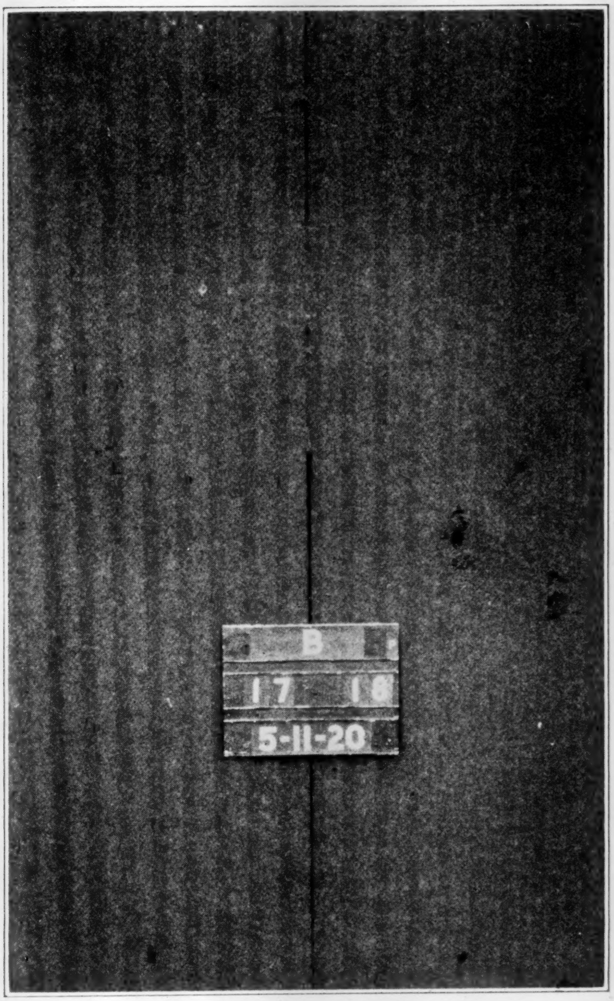


FIG. 41.—PITTSBURGH TESTS.

NO. 22 GAGE OPEN-HEARTH STEEL—SERIES A.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
B 17........	0.06	0.24	0.010	0.065	0.003	0.169	....
B 18........	0.04	0.24	0.021	0.063	0.003	0.178	....

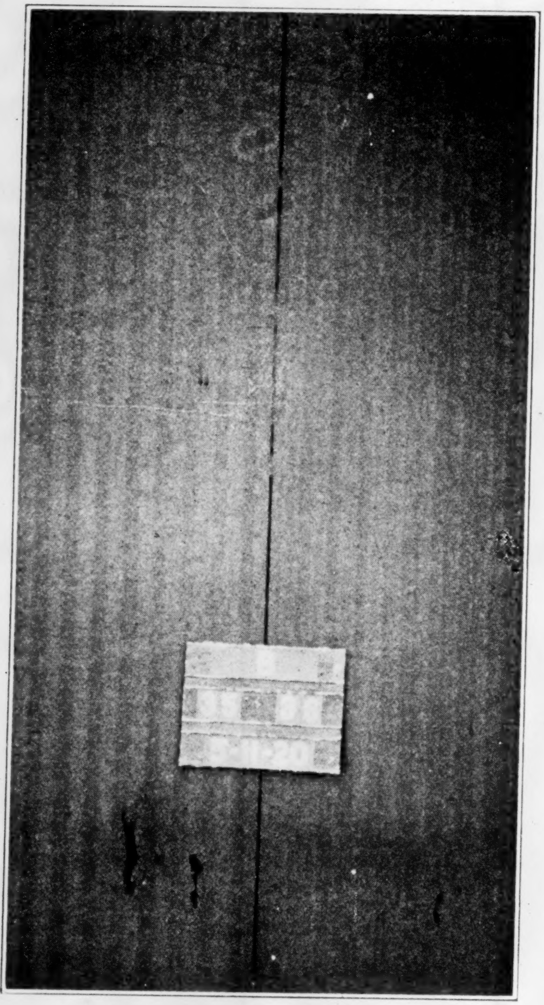


FIG. 42.—PITTSBURGH TESTS.

NO. 22 GAGE OPEN-HEARTH STEEL—SERIES A.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
B 35........	0.10	0.40	0.017	0.077	0.042	0.090	0.055
B 36........	0.10	0.40	0.017	0.077	0.014	0.078	0.055

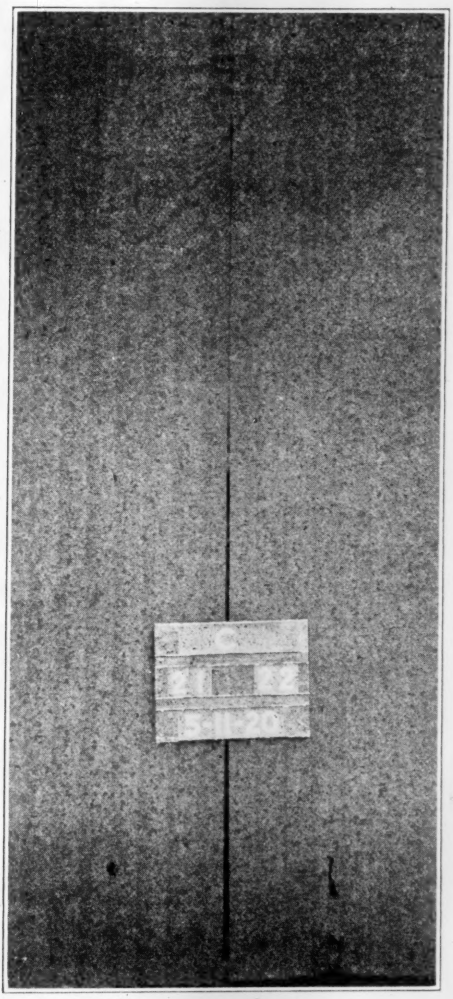


FIG. 43.—PITTSBURGH TESTS.

NO. 22 GAGE COPPER-BEARING PURE IRON—SERIES A.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
C 21........	0.01	0.028	0.002	0.027	0.002	0.137	0.048
C 22........	0.06	0.04	0.005	0.034	0.004	0.19	0.015

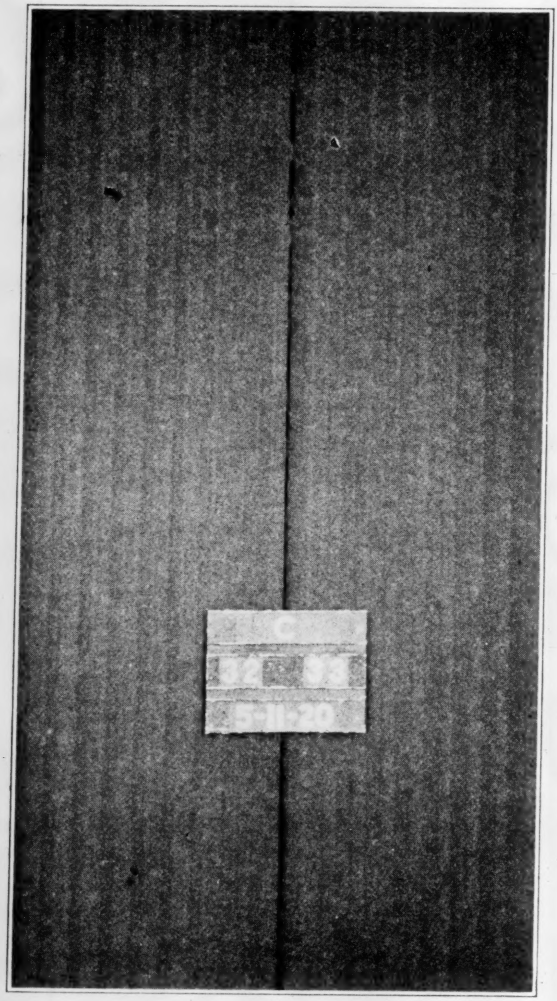


FIG. 44.—PITTSBURGH TESTS.

NO. 22 GAGE COPPER-BEARING PURE IRON—SERIES A.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel., per cent.
C 32........	0.02	0.02	0.005	0.027	0.009	0.17	....
C 33........	0.02	0.02	0.004	0.033	....	0.17	0.012

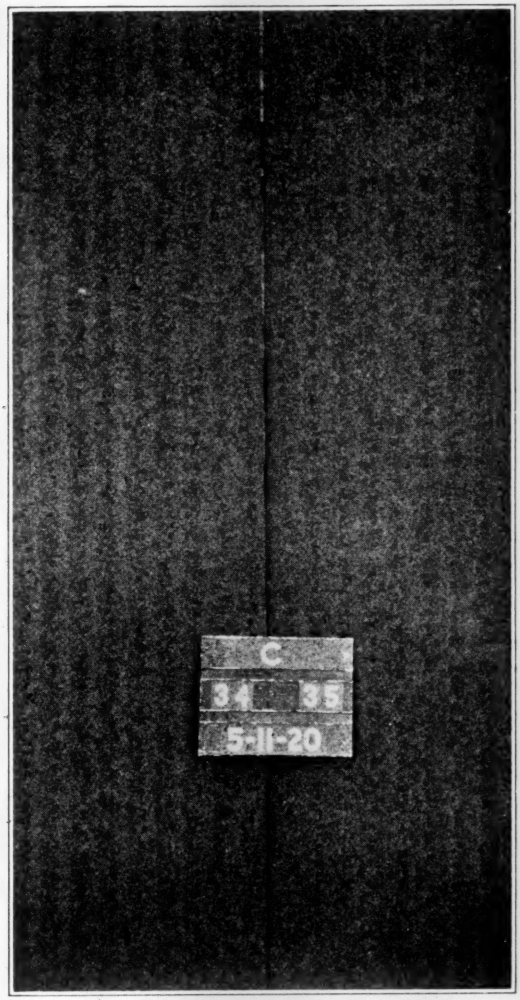


FIG. 45.—PITTSBURGH TESTS.

NO. 22 GAGE COPPER-BEARING PURE IRON—SERIES A.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
C 34........	0.02	0.02	0.004	0.031	....	0.17	....
C 35	0.02	0.02	0.005	0.031	....	0.17	....

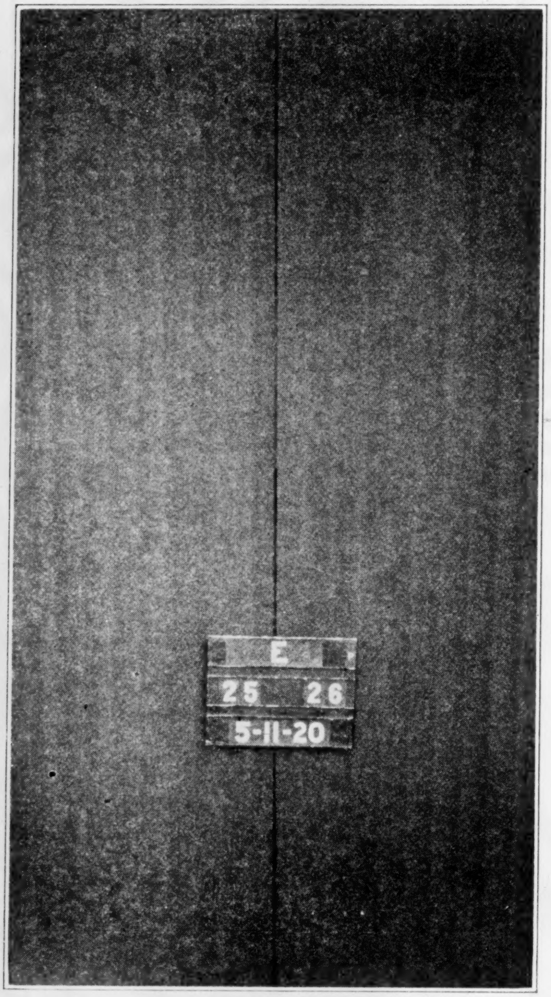


FIG. 46.—PITTSBURGH TESTS.

NO. 22 GAGE PUDDLED IRON—SERIES A.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
E 25........	0.04	0.05	0.101	0.019	0.11	0.31	0.03
E 26........	0.05	0.07	0.127	0.020	0.15	0.32	0.03

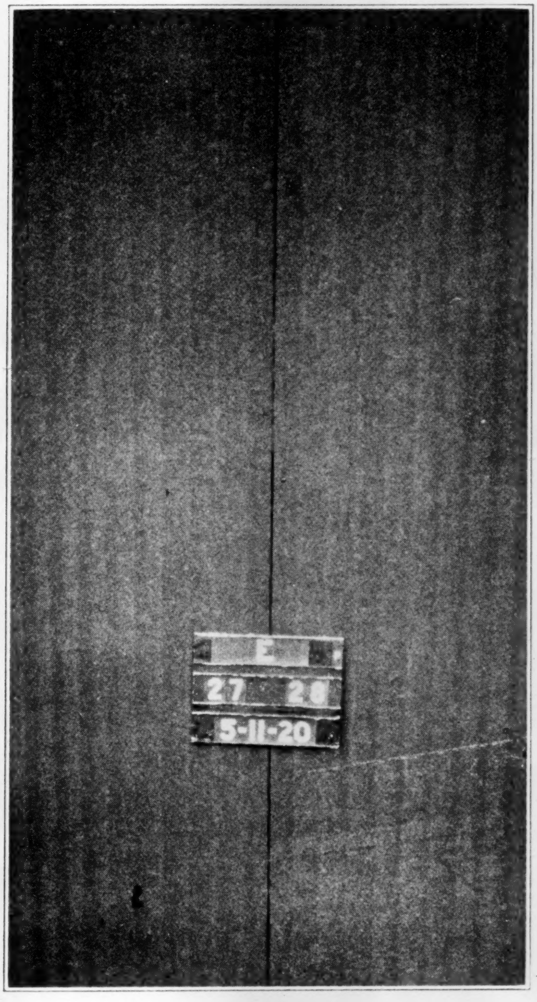


FIG. 47.—PITTSBURGH TESTS.

NO. 22 GAGE PUDDLED IRON—SERIES A.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
E 27........	0.02	0.06	0.120	0.021	0.14	0.32	0.04
E 28........	0.03	0.06	0.124	0.023	0.14	0.31	0.03

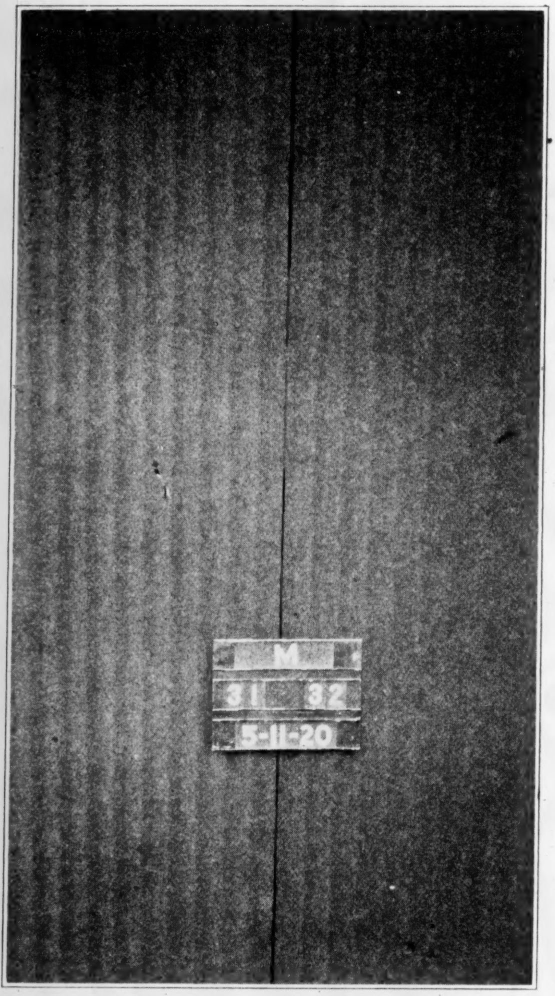


FIG. 48.—PITTSBURGH TESTS.

NO. 22 GAGE OPEN-HEARTH STEEL—SERIES B.

Alan Wood Iron and Steel Co.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
M 31........	0.11	0.52	0.005	0.047	....	0.178	None
M 32.......	0.10	0.52	0.007	0.051	...	0.16	None

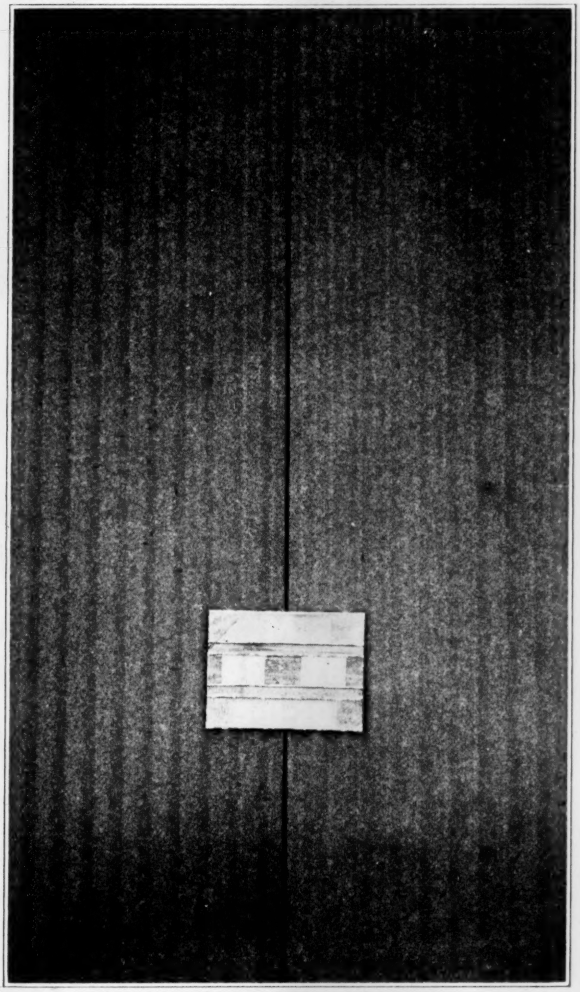


FIG. 49.—PITTSBURGH TESTS.

NO. 22 GAGE OPEN-HEARTH STEEL—SERIES B.

Alan Wood Iron and Steel Co.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
M 35.......	0.10	0.43	0.006	0.046	....	0.172	None
M 36.......	0.10	0.52	0.007	0.042	....	0.168	None

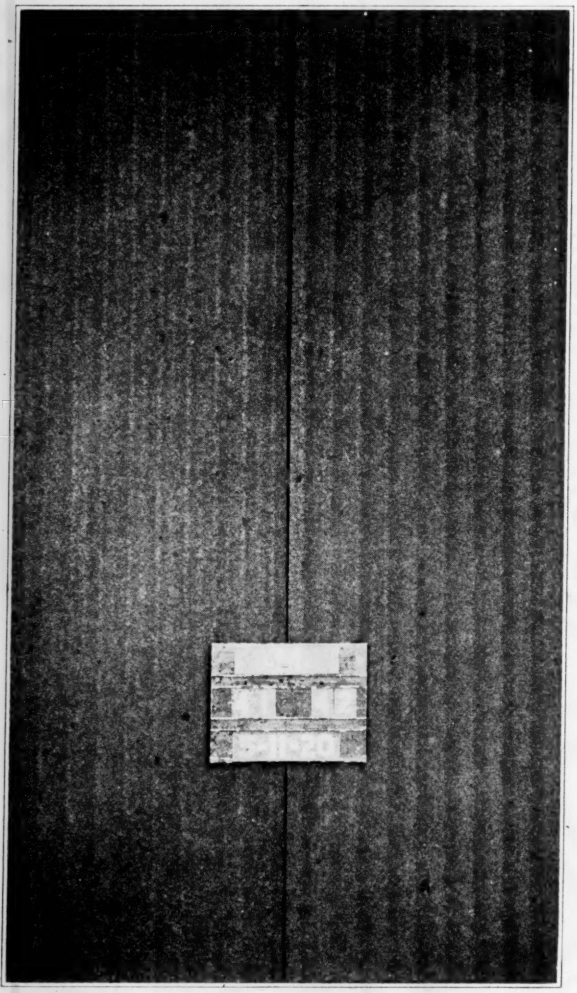


FIG. 50.—PITTSBURGH TESTS.

NO. 22 GAGE OPEN-HEARTH STEEL—SERIES B.

Alan Wood Iron and Steel Co.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
M 41.......	0.075	0.40	0.017	0.040	0.005	0.20	None
M 42.......	0.085	0.42	0.015	0.040	0.006	0.20	None

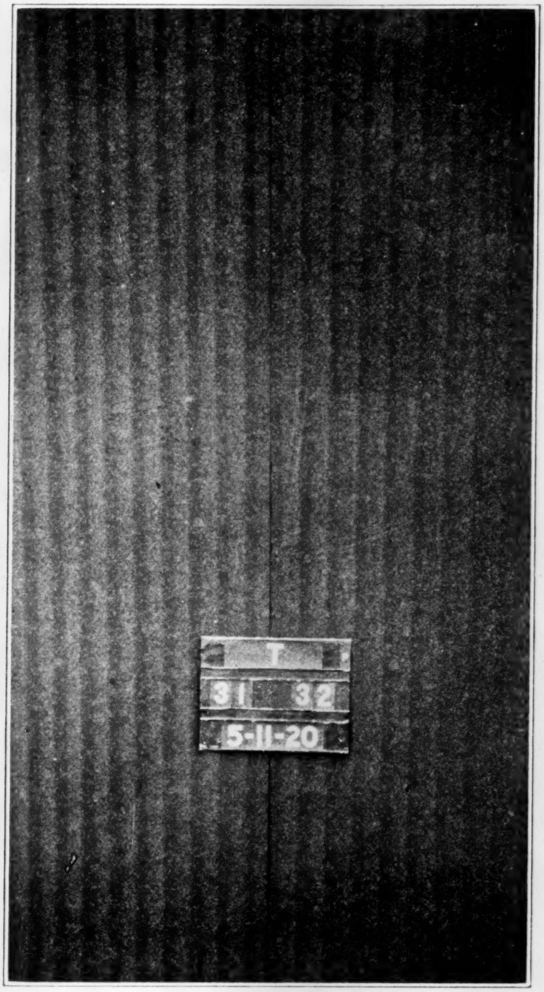


FIG. 51.—PITTSBURGH TESTS.

NO. 22 GAGE COPPER-BEARING STEEL—SERIES B.

Newport Rolling Mill Co.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent
T 31........	0.091	0.299	0.009	0.019	....	0.209	None
T 32........	0.10	0.32	0.006	0.025	0.001	0.226	None

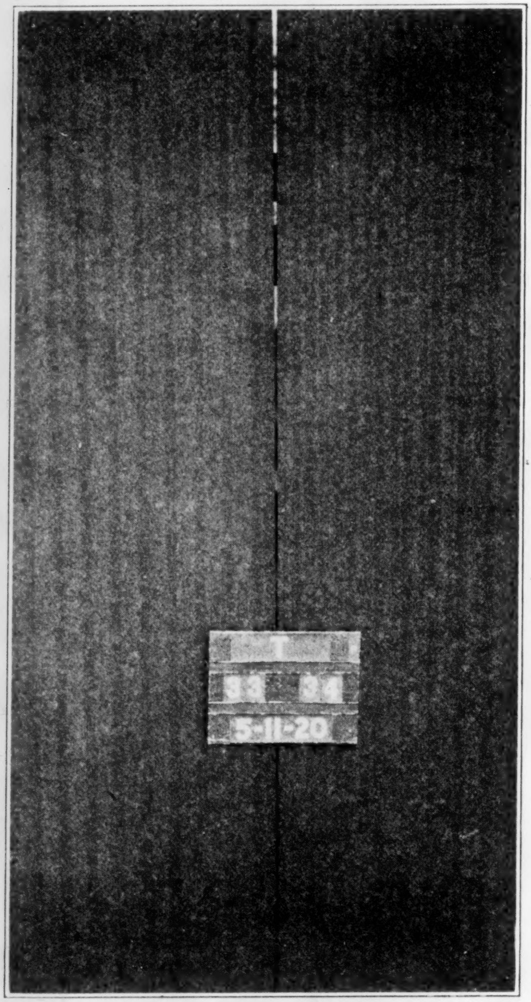


FIG. 52.—PITTSBURGH TESTS.

NO. 22 GAGE COPPER-BEARING STEEL—SERIES B.

Newport Rolling Mill Co.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
T 33........	0.10	0.32	0.006	0.022	....	0.228	None
T 34........	0.10	0.34	0.006	0.024	....	0.212	None

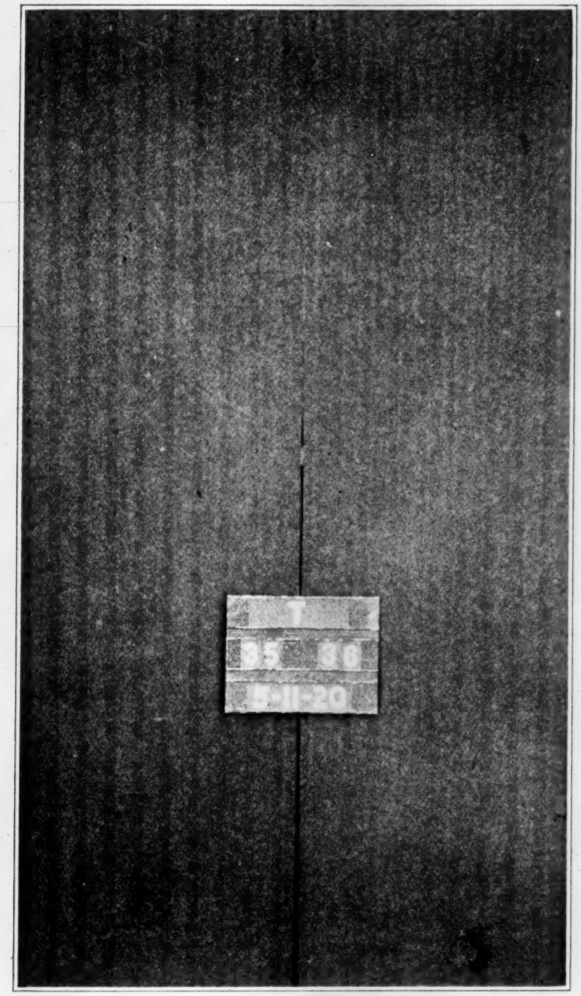


FIG. 53.—PITTSBURGH TESTS.

NO. 22 GAGE COPPER-BEARING STEEL—SERIES B.

Newport Rolling Mill Co.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
T 35..........	0.10	0.34	0.006	0.022	0.003	0.226	None
T 36..........	0.08	0.30	0.009	0.023	Trace	0.21	None

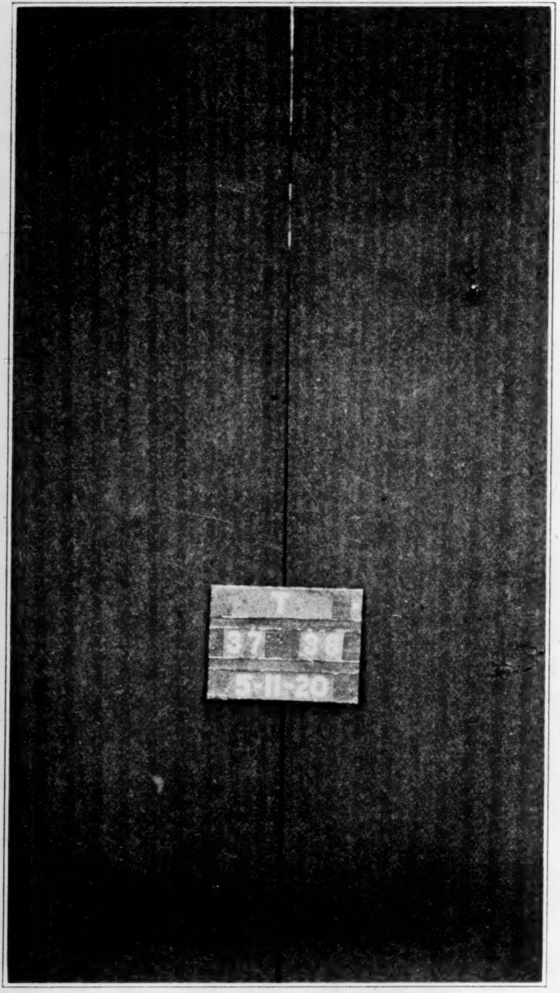


FIG. 54.—PITTSBURGH TESTS.

NO. 22 GAGE COPPER-BEARING STEEL—SERIES B.

Newport Rolling Mill Co.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
T 37........	0.07	0.30	0.009	0.021	Trace	0.23	None
T 38........	0.07	0.32	0.010	0.024	Trace	0.21	None

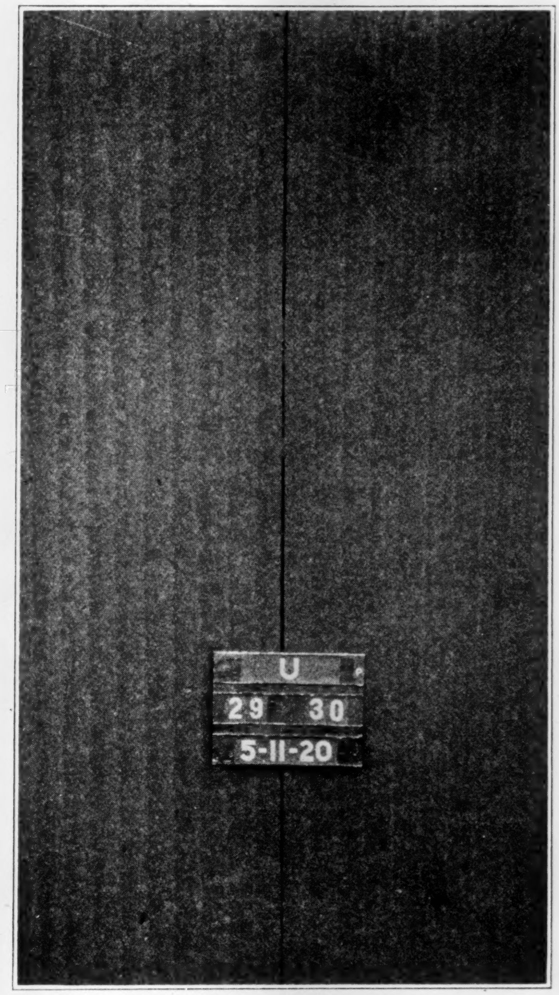


FIG. 55.—PITTSBURGH TESTS.

NO. 22 GAGE COPPER-BEARING PURE IRON—SERIES B.

Allegheny Steel Co.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent
U 29........	0.006	0.06	0.013	0.048	....	0.26	....
U 30........	0.012	0.066	0.008	0.037	....	0.257	0.011

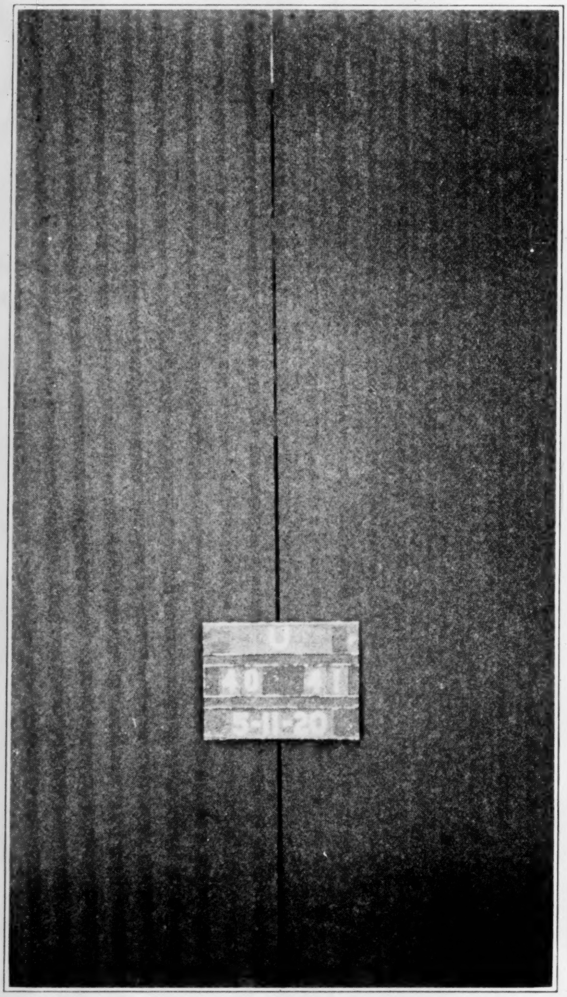


FIG. 56.—PITTSBURGH TESTS.

NO. 22 GAGE COPPER-BEARING PURE IRON—SERIES B.

Allegheny Steel Co.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
U 40........	0.01	0.07	0.007	0.040	Trace	0.27	None
U 41........	0.005	0.07	0.008	0.037	Trace	0.28	None

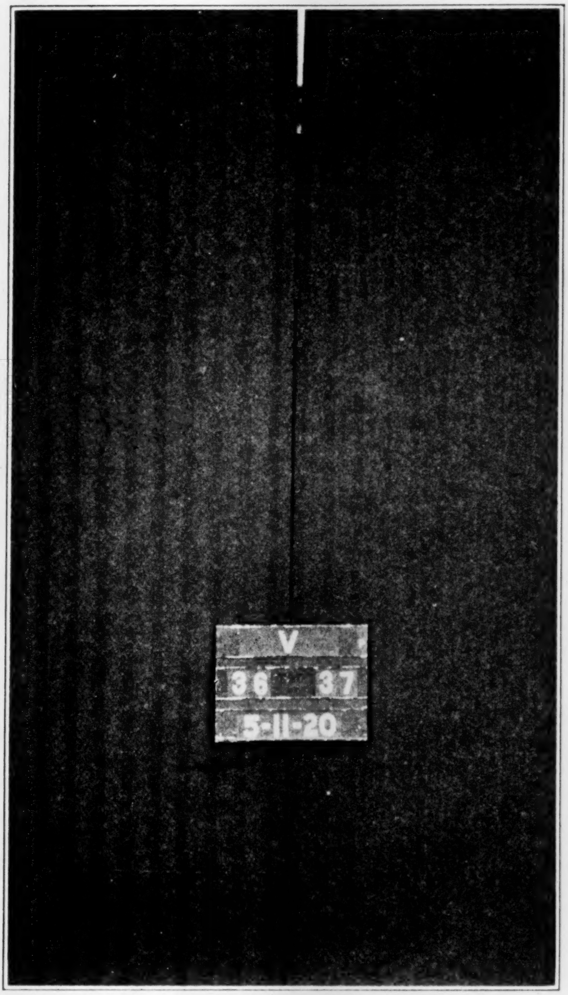


Fig. 57.—Pittsburgh Tests.

No. 22 Gage Copper-Bearing Pure Iron—Series B.

Whitaker-Glessner Co.

Sheet.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
V 36........	0.01	0.06	0.008	0.023	Trace	0.33	None
V 37........	0.01	0.05	0.007	0.023	Trace	0.31	None

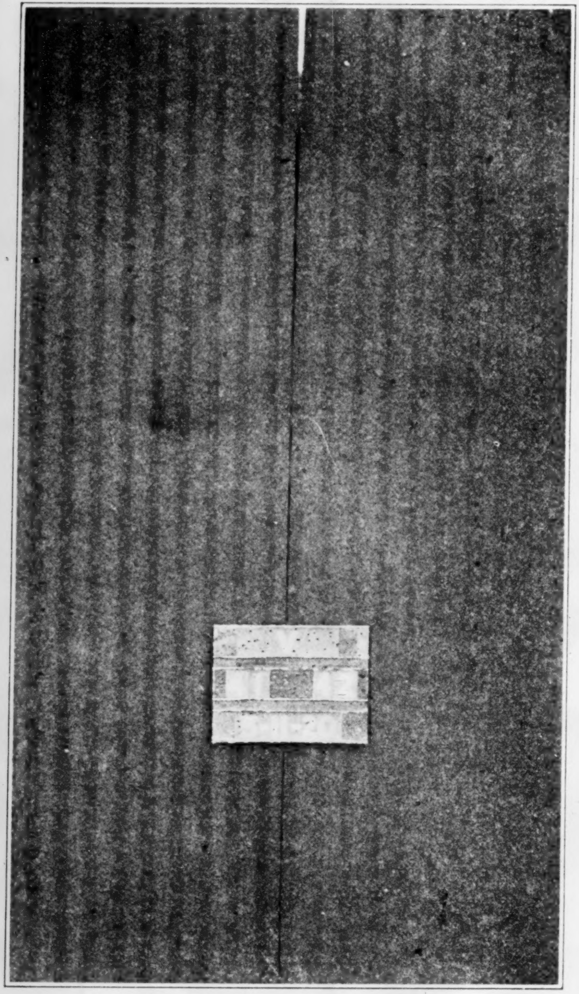


FIG. 58.—PITTSBURGH TESTS.

NO. 22 GAGE COPPER-BEARING PURE IRON—SERIES B.

Whitaker-Glessner Co.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
V 41........	0.02	0.06	0.007	0.019	Trace	0.28	None
V 42........	0.02	0.08	0.007	0.021	Trace	0.31	None

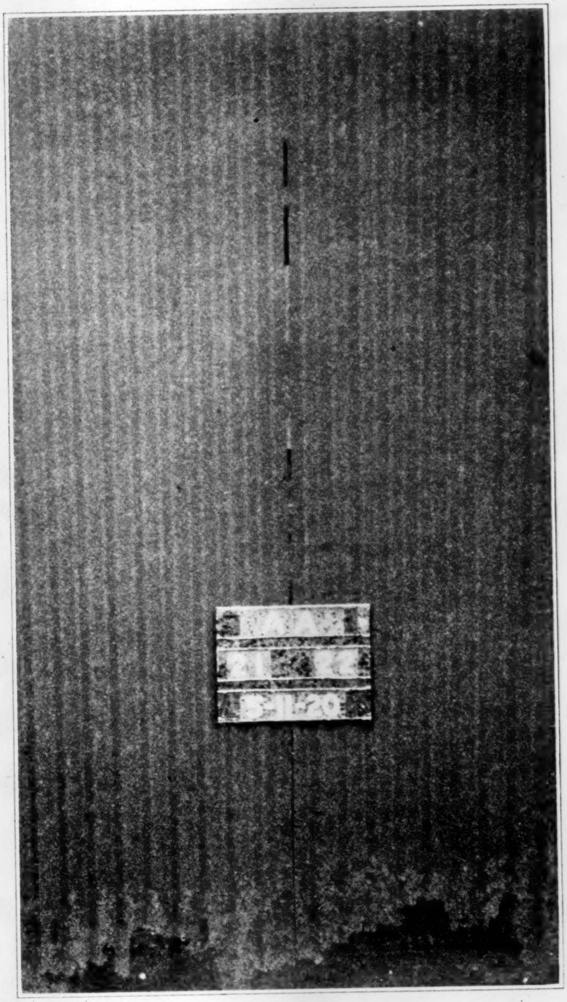


FIG. 59.—PITTSBURGH TESTS.

NO. 16 GAGE BESSEMER STEEL—SERIES A.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
AA 21.......	0.018	0.40	0.085	0.043	0.004	0.010	....
AA 22.......	0.022	0.42	0.085	0.041	0.002	0.010	....

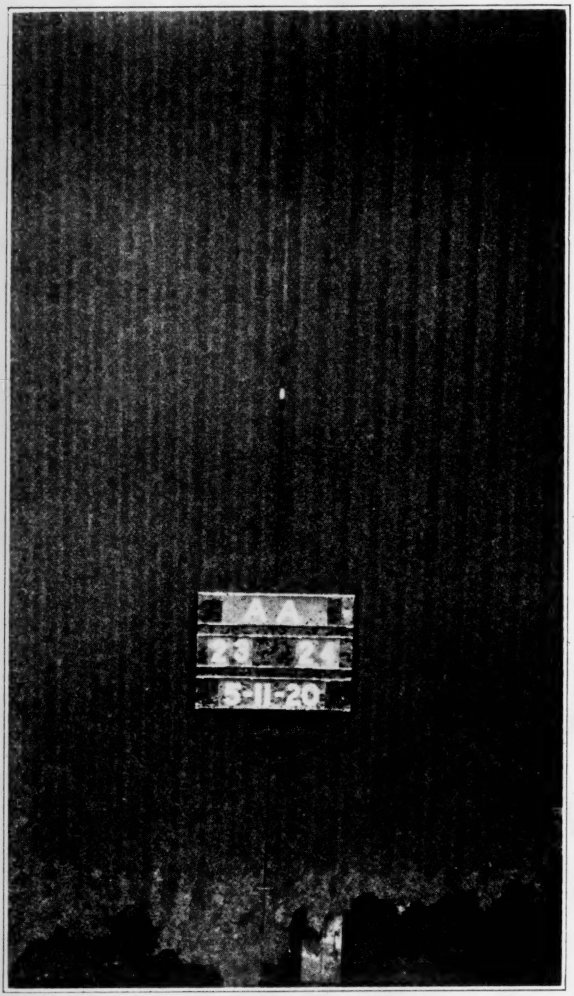


FIG. 60.—PITTSBURGH TESTS.

NO. 16 GAGE BESSEMER STEEL—SERIES A.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
AA 23......	0.034	0.42	0.084	0.041	0.004	0.010	....
AA 24......	0.018	0.41	0.086	0.041	0.002	0.010	....

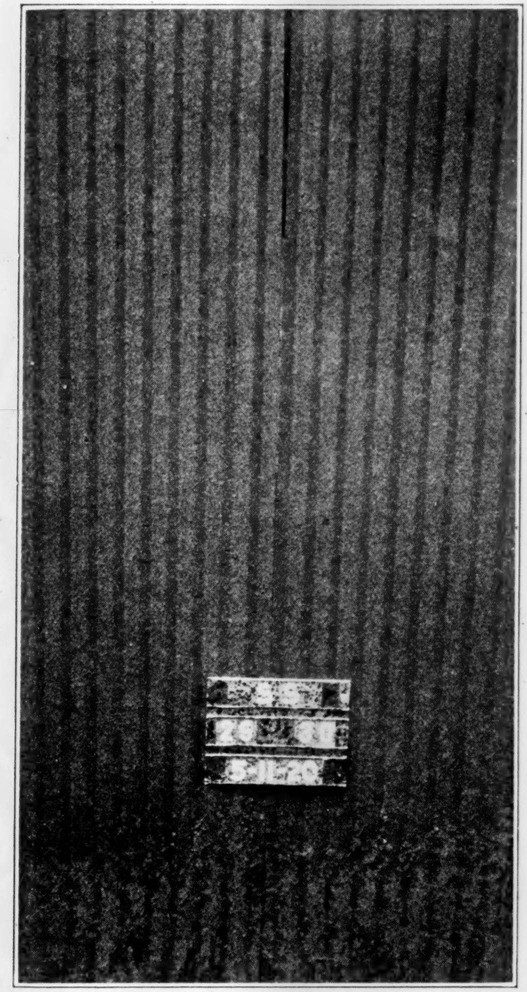


FIG. 61.—PITTSBURGH TESTS.

NO. 16 GAGE LOW-COPPER PURE IRON—SERIES B.

American Rolling Mill Co.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
SS 29........	0.021	0.013	0.005	0.018	.....	0.026	Trace
SS 30........	0.018	0.011	0.005	0.019	0.006	0.025	Trace

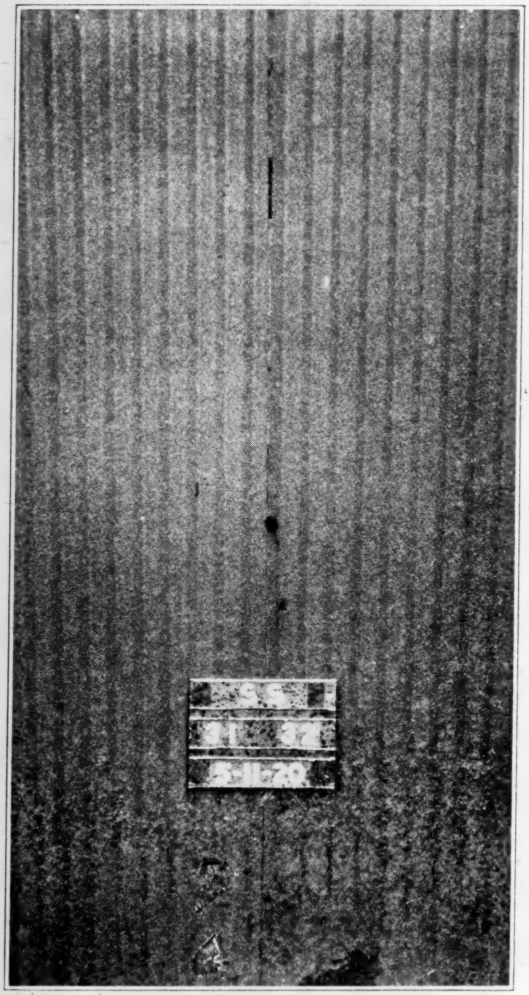


FIG. 62.—PITTSBURGH TESTS.

NO. 16 GAGE LOW-COPPER PURE IRON—SERIES B.

American Rolling Mill Co.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
SS 31.......	0.02	0.018	0.004	0.023	0.003	0.024	None
SS 32.......	0.02	0.018	0.003	0.026	....	0.024	None

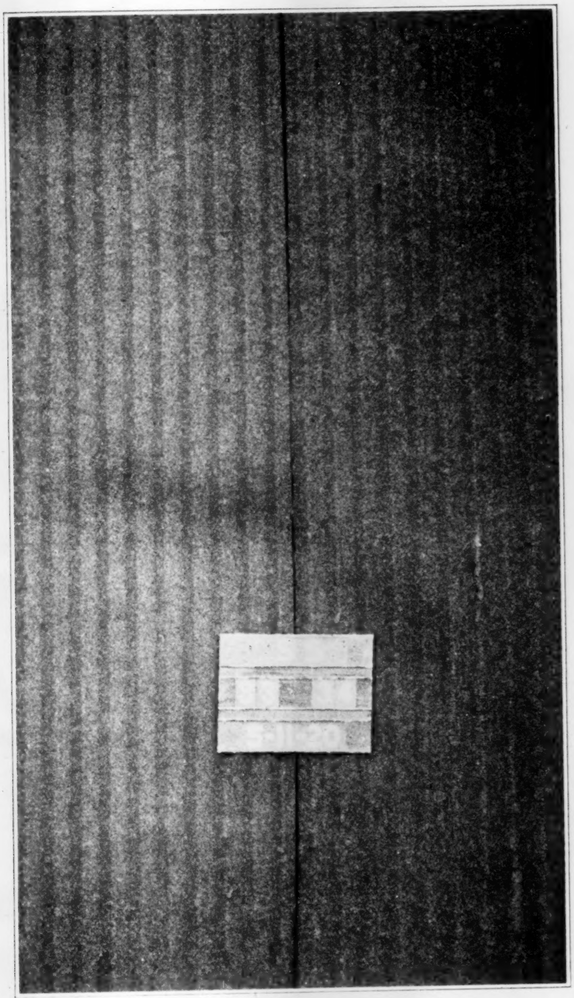


FIG. 63.—PITTSBURGH TESTS.

NO. 16 GAGE LOW-COPPER PURE IRON—SERIES B.

American Rolling Mill Co.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
SS 33.......	0.02	0.018	0.003	0.029	....	0.027	None
SS 34.......	0.02	0.018	0.004	0.023	0.002	0.020	None

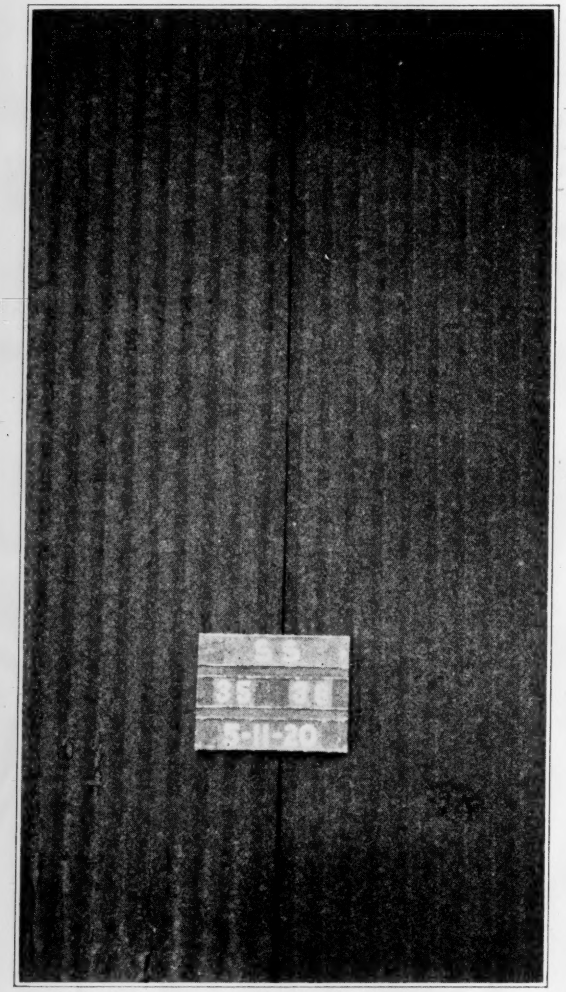


FIG. 64.—PITTSBURGH TESTS.

NO. 16 GAGE LOW-COPPER PURE IRON—SERIES B.

American Rolling Mill Co.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
SS 35.......	0.02	0.02	0.007	0.028	Trace	0.03	None
SS 36.......	0.005	0.02	0.005	0.025	Trace	0.022	None

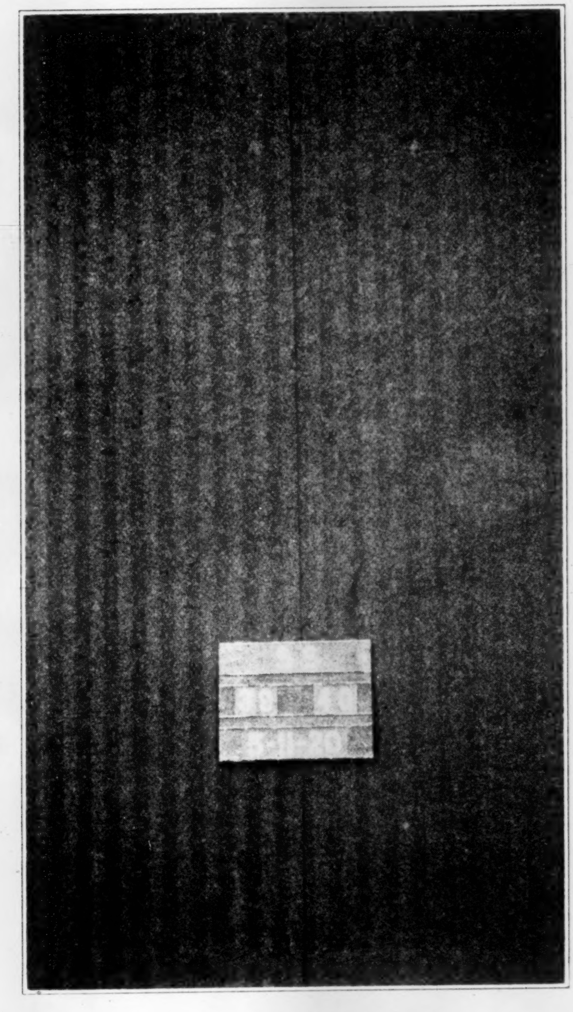


FIG. 65.—PITTSBURGH TESTS.

NO. 16 GAGE LOW-COPPER PURE IRON—SERIES B.

American Rolling Mill Co.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
SS 39.......	0.01	0.02	0.005	0.025	Trace	0.03	None
SS 40.......	0.01	0.02	0.006	0.025	Trace	0.03	None

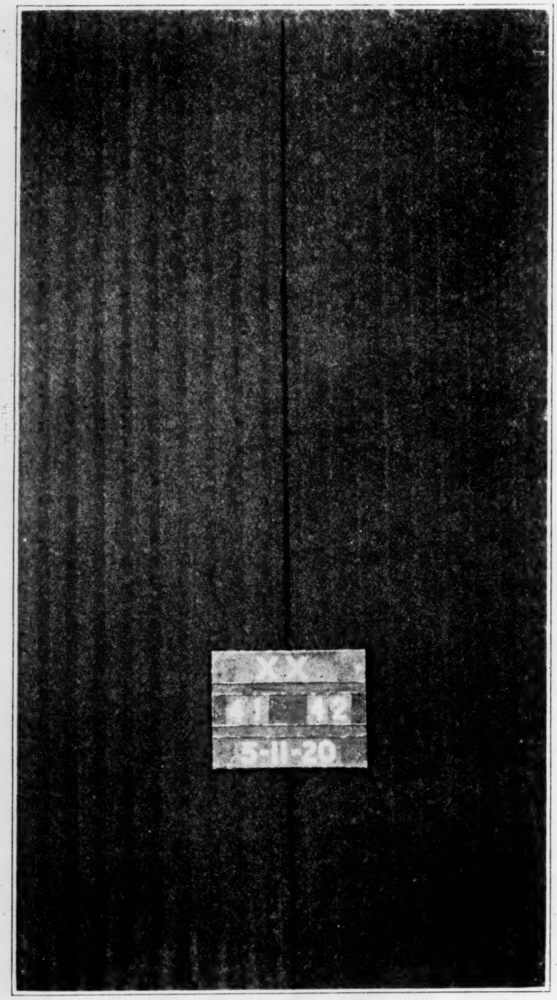


FIG. 66.—PITTSBURGH TESTS.

NO. 16 GAGE LOW-COPPER PURE IRON—SERIES B.

Inland Steel Co.

SHEET.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.	Silicon, per cent.	Copper, per cent.	Nickel, per cent.
XX 41......	0.015	0.06	0.006	0.041	Trace	0.025	None
XX 42......	0.020	0.08	0.006	0.031	Trace	0.025	None

REPORT OF SUB-COMMITTEE V ON TOTAL IMMERSION TESTS.

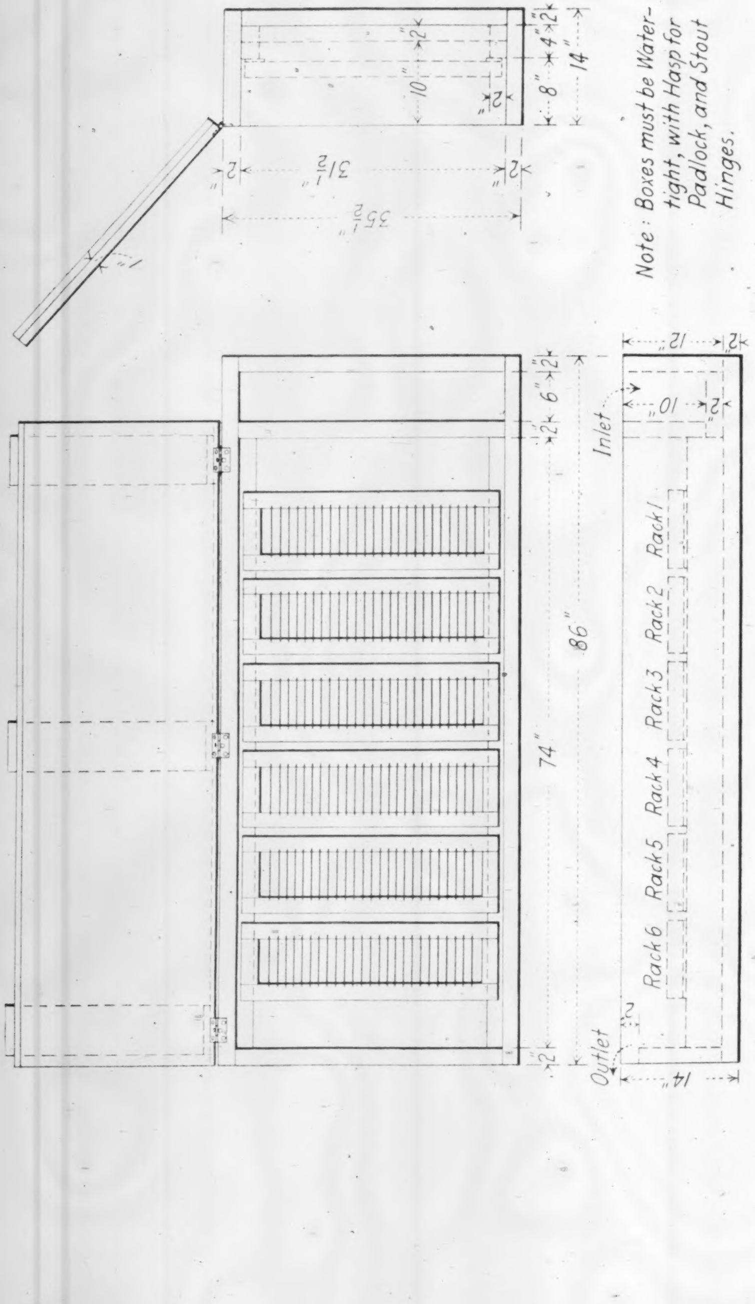
Sub-Committee V on Immersion Tests has had several meetings and frequent correspondence and can report considerable progress.

Committee A-5, before making a final report on the rust resisting qualities of the various grades of metal which are exposed to the atmosphere on the three racks which they have at Annapolis, Pittsburgh and Fort Sheridan, thought it was advisable to find how samples from these identical sheets would act when exposed to running water. Sub-Committee V was accordingly appointed to have charge of these tests.

At the Bureau of Standards, pieces 2 in. wide, cut from each of the sheets which are exposed in the various racks have been preserved; and the plan of the sub-committee is to cut from these strips, test pieces 2 by 6 in. from the various grades of metal, and expose them to the action of running water: first, at the Bureau of Standards, Washington, D. C., to determine the effect of normal city water supply; second, at the Engineering Experiment Station, United States Naval Academy, Annapolis, Maryland, for the effect of the brackish water of the Chesapeake Bay; and third, under the care of the Bureau of Mines in the Pittsburgh district, for the effect of the drainage water from a coal mine.

At each of these stations there will be two boxes: one for the No. 16 gage samples of which there will be six samples from each of the 25 grades of metal, and the other box for the No. 22 gage samples, of which there will be six samples from each of the 24 grades of metal. This will make 450 samples of the No. 16 gage and 432 samples of the No. 22 gage in the complete test.

In each box there will be six racks, with one sample from each grade of metal in a rack, but the samples are so placed in the racks that in no one box will they be in the same order; consequently, no one grade of metal will be in a favorable or unfavorable position in regard to being in the middle or at the edge of the box in all the racks. These boxes will be kept under lock and key, and only opened for the periodical inspections.


2"
4"
2"
8"
14"
10"
2"
2"
31½"
2"
35½"
1"
2"
6"
2"
86"
74"
2"
Inlet
Outlet
Rack 1
Rack 2
Rack 3
Rack 4
Rack 5
Rack 6
12"
2"
10"
2"
2
14"

Note: Boxes must be Water-tight, with Hasp for Padlock, and Stout Hinges.

FIG. 1.—Box for Immersion Tests.

The sub-committee has sent to the various stations, blue prints giving the exact order and location in which the test pieces are to be placed in the racks, and the racks in the boxes, also the following instructions for installing the tests.

All the double letter (No. 16 gage) test pieces are to be put in one box and all the single letter (No. 22 gage) test pieces are to be put in the other box.

Great care must be used to place the specimens in the racks in the order given on the blue prints, as this is the only way in which the record of the pieces can be preserved. Save the blue prints for use in reporting on the samples.

The racks must be numbered plainly and cut deeply in the wood as follows: I, II, III, IV, V, VI, and placed in the boxes in the order as shown on blue print of box,—rack I being at the inlet end.

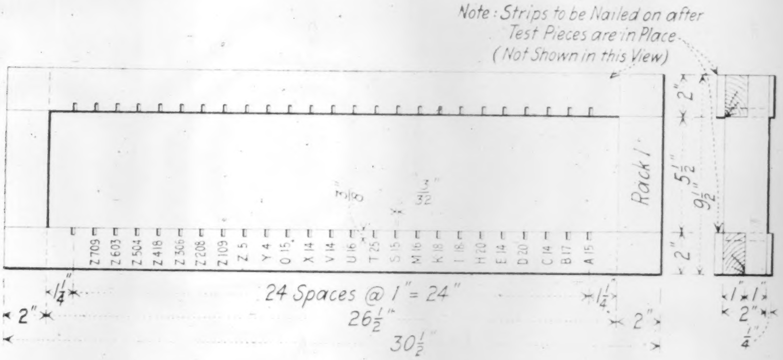

Note: Strips to be Nailed on after Test Pieces are in Place (Not Shown in this View)
Rack I
Z 709
Z 603
Z 504
Z 418
Z 306
Z 208
Z 109
Z 5
Y 4
O 15
X 14
V 14
U 16
T 25
S 15
M 16
K 18
I 18
H 20
E 14
D 20
C 14
B 17
A 15
3/8"
3/32"
2"
5 1/2"
9 1/2"
2"
1 1/4"
24 Spaces @ 1" = 24"
1 1/4"
2"
26 1/2"
2"
30 1/2"
1"
1"
2"
1/4"

FIG. 2.—Detail View of One Rack for Immersion Tests.

After the test pieces are placed in the racks, a thin strip of wood should be nailed over both ends of the test pieces so that the test pieces cannot be taken out and misplaced. It may be necessary at times of inspection to remove these strips, when care must be used to get the test pieces back in the racks in the order given on blue prints, and strips replaced.

If the weight of the racks and test pieces do not keep the racks from floating on the surface of the water, the racks must have weights on ends or strips nailed to the sides of the boxes to keep them submerged and in place.

In making reports give the initial and numbers on the test, and the rack number also, as several tests are cut from the same plate and have the same serial number.

Great care must be used in the installation and inspection, and reports on the conditions of the test pieces, as there must be no danger of any mix-up in the results.

The sub-committee has also sent to each station the following specifications for the immersion tests:

1. The flow of water at the inlet should be regulated to a rate of about 6 gal. per minute and maintained at that rate as nearly as possible and the box containing the test pieces should be placed level so that the overflow is of even depth over the entire width of the outlet.

2. The analysis should be made of the water at the inlet to the boxes every month for:

(*a*) Free oxygen in cubic centimeters per liter.

(*b*) Alkalinity or acidity using both phenol phthalein and methyl orange as indicators expressing the results in p.p.m.

(*c*) The temperature should be registered at time of taking samples.

3. The tests in the mining district should be made in water that is not too high in acidity at any time and should be inspected about every two weeks. The tests at Annapolis and at the Bureau of Standards, Washington, should be inspected at least once a month. In making inspection, test pieces should be disturbed as little as possible and all treated alike. The tests will be considered to be finished when an indentation of $\frac{1}{8}$ in. in depth appears on the edges of the plates, or a perforation develops in the body of the test plates, or where one of the test pieces fails completely so that it drops out of its grooves in the rack. When one of the test pieces in any of the tests shows a decided indication of failure in this way, this test piece shall be considered finished and the sample removed to the laboratory for cleaning and inspection. The samples should of course not be taken out of the test racks unless they are carefully marked at the same time with identification marks which will be placed on the side of the racks.

4. Complete notes of any developments found at the time of inspection should be made in detail and report forwarded to Mr. W. A. Cooper, Chairman of Sub-Committee V of Committee A-5, in care of Alan Wood Iron and Steel Co., Conshohocken, Pa.

NOTE.—The test boxes will hold about 96 gal. and a flow of 6 gal. per minute will change the water about every 16 minutes.

The test pieces have been forwarded to the various stations. The boxes are under construction and the tests should be installed in a very short time.

Respectfully submitted on behalf of the sub-committee,

WILLIAM A. COOPER,
Chairman.

REPORT OF COMMITTEE A-8

ON

MAGNETIC ANALYSIS.

A number of investigations are being carried on by members of the committee, but no definite report of completed work will be made this year. These investigations include work on rails, wires, cables, rods, gears, and forgings.

The work of P. H. Dudley of the New York Central Railroad has been continued. One hundred and two rails of the 6-in. 105-lb. Dudley section in standard lengths of 33 ft. have been accumulated at the Harmon Electric Shops of the New York Central Railroad for magnetic surveys and other test purposes. Twenty-seven of these rails have recently been surveyed. The curves obtained as records of permeability have deflections of somewhat greater magnitude than were obtained on the new rails of good quality which were tested some time previously, and reported on at the last annual meeting of the Society.[1] The 27 rails tested to date were all rejected at the plant of manufacture on account of brittleness and failure to meet the drop test requirements of the specifications of the New York Central Railroad. This probably accounts for the more erratic and larger deflections obtained on this lot of 27 rails.

Included in the 102 rails are 24 rolled from four ingots of one melt of steel. Two of the ingots were rolled direct to rails without reheating of the blooms, making twelve rails. The other two ingots were bloomed, reheated, and rolled to rails. Surveys are to be made on these rails for comparative purposes A marked difference in service and quality of rails rolled from reheated blooms as compared to those rolled direct from the ingot has been the experience in the track. The object of making magnetic surveys on rails rolled direct and from the reheated blooms is to detect magnetically differences in properties and homogeneity of the rails rolled under the two methods of manufacture.

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[1] P. H. Dudley, "Magnetic Surveys on New and Failed Rails," *Proceedings*, Am. Soc. Test. Mats., Vol. XIX, Part II, p. 51 (1919).

A number of changes have been made in the apparatus and recording mechanism to simplify testing. The changes do not affect the character of the curves obtained, nor the magnitude of the deflections. The camera box has been reconstructed so that the film is made to travel at a uniform rate in front of the slit through which the beam of light is admitted. Friction rolls are used to drive the moving film.

Continued progress is thus being made in the study of rail steel by means of magnetic testing apparatus, and greater interest is being shown in the work. The surveys on rails will be continued at the Harmon Shops and the work broadened and the equipment improved if possible.

The General Electric Co. has initiated a magnetic investigation of steel forgings with special reference to turbine bucket wheels. This work is being prosecuted actively and the results are very encouraging. The presence of flaws and segregations and the general degree of perfection of the forging is indicated by the magnetic test.

At the Bureau of Standards especial attention has been given to the study of the correlation between the magnetic properties and the structure and other physical properties of steel. An extended investigation along this line is now in progress. The first report on this investigation is given in a forthcoming *Scientific Paper* by Nusbaum, Cheney and Scott on "The Magnetic Reluctivity Relationship as a Criterion of the Structure of a Eutectoid Carbon Steel." A brief discussion of this subject has already been presented before the American Institute of Mining and Metallurgical Engineers.

New and improved apparatus has been designed and constructed for the determination of the degree of magnetic uniformity along the length of steel bars and tubes and a number of practical applications of this method have been made.

Special apparatus for the testing of irregular shapes has also been the subject of study and some methods and instruments are now in process of development.

One member of the committee, Mr. S. R. Williams, has completed a joint investigation with Sir Robert Hadfield on "Magnetic-Mechanical Analysis of Manganese Steel."

A manufacturer of automobiles has undertaken a magnetic investigation of steel driving pinions. This work has not as yet progressed far enough to give any information on the extent to which the magnetic test can be applied to this class of specimen.

Progress has been made in the magnetic examination of simple welded joints.

In addition to the investigation of material, considerable work has been done in the perfection of the existing types of apparatus and in the development of new types.

This report has been submitted to letter ballot of the committee, which consists of 16 members, of whom 10 have voted affirmatively, 1 negatively, and 5 have refrained from voting.

Respectfully submitted on behalf of the committee,

C. W. BURROWS,
Chairman.

R. L. SANFORD,
Secretary.

REPORT OF COMMITTEE B-2
ON
NON-FERROUS METALS AND ALLOYS.

Committee B-2 is continuing its work on the same plan as last year and begs to submit the following account of its activities, comprising reports from the various sub-committees which were accepted at the last meeting of the committee, on April 19, 1920.

Sub-Committee I on Pure Metals in Ingot Form.—This sub-committee has confined itself to the question of Pig Lead. Specifications for Tin were proposed but, on account of the fact that we are unable to get in touch with the tin producers, and that all the tin is purchased by brand through brokerage houses, it does not seem advisable to undertake the formulation of specifications. The situation as outlined by Mr. Addicks for the committee in their report for 1916[1] is substantially correct for present conditions.

Its chairman, Mr. Bassett, reported that Sub-Committee I had further considered the Tentative Specifications for Lead (B 29 - 19 T) and submitted revisions which are given in the Appendix to this report. There are still some differences of opinion in regard to the chemical composition of Corroding Lead and as to the best practice in Chemical Lead, which should be reconciled. Committee B-2 therefore recommends that these specifications, as thus revised, be published as tentative for at least another year.

Sub-Committee II on Wrought Metals.—Mr. W. R. Webster, chairman, presented the report of his sub-committee with new Tentative Specifications for Sheet High Brass which are appended hereto.[2] In pursuance of the recommendations of the sub-committee, Committee B-2 recommends that they be accepted by the Society for publication as tentative.

Sub-Committee III on Sand-Cast Alloys.—This sub-committee reports progress. The two new tentative specifications presented last year covering Brass Ingot Metal for Sand Castings

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XVI, Part I, p. 197 (1916).

[2] See p. 580.—Ed.

(B 30 - 19 T),[1] and Bronze Bearing Metal in Ingot Form (B 31 - 19 T),[2] are still being discussed. The question of composition for the various grades has not yet been settled, and it is recommended that these specifications be held tentative.

Criticisms of these two specifications as well as others have been received from the Engineering Division, Aircraft Service, War Department.

The committee further recommends that the present Tentative Specifications for Bronze Bearing Metals for Turntables and Movable Railroad Bridges (B 22 - 18 T)[3] be continued as tentative.

Sub-Committee IV on White Metals.—This sub-committee reports progress. Work on the correct pouring temperature of babbitt metals is being continued.

It is recommended that the Tentative Specifications for Solder Metal (B 32 - 19 T)[4] presented last year and the Tentative Specifications for White Metal Bearing Alloys (B 23 - 18 T)[5] be continued as tentative.

Sub-Committee V on Plates, Tubes and Stay Bolts for Locomotives.—At a meeting of Committee A-2 on Wrought Iron held in Philadelphia March 26, 1920, a resolution was passed changing the tolerances of staybolt iron in the Standard Specifications for Staybolt Iron (A 39 - 18)[6] to read as follows:

> "The bars shall be truly round within 0.01 in., and shall not vary more than 0.01 in. above nor more than 0.005 in. below the specified size."

This necessitates a change in the Standard Specifications for Copper Bars for Locomotive Staybolts (B 12 - 18)[6], as the tolerance now given will not permit of cutting a full thread if the material is received below tolerance. It is therefore recommended that Section 9 of Specifications B 12 - 18 be changed to read as indicated above, the revision to be published first as tentative for one year. (See Appendix to this report.)

Sub-Committee VI on Non-Ferrous Alloys for Railway Equipment.—The revision of the Tentative Specifications for Non-Ferrous Alloys for Railway Equipment (B 17 - 18 T)[7] has been further considered. It is felt that these alloys are still in the process of change and the committee therefore recommends that these specifications be continued as tentative.

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[1] See p. 561.
[2] See p. 565.
[3] See p. 533.
[4] See p. 569.
[5] See p. 538.
[6] 1918 Book of A.S.T.M. Standards.
[7] See p. 528.

Sub-Committee VII on Methods of Analysis.—Mr. W. A. Cowan, chairman, reported that the present Tentative Methods for Chemical Analysis of Alloys of Lead, Tin, Antimony and Copper (B 18 – 17 T)[1] have been held tentative for three years. A great deal of work on comparison of methods by analysis of standard samples has been done by members of the sub-committee and by several cooperating chemists. As a result of this work the sub-committee has recommended a revision of these methods, as follows:

> Addition of a paragraph giving "General Considerations," explaining where the methods are applicable; the General Method I to be retained as such after proper changes in style to conform to other A.S.T.M. methods;
>
> Section II to be headed "Rapid Method for Control Work" and changed to a combination of the Demorest and Stief methods, giving determination of lead and copper on one portion and of arsenic, antimony and tin on a separate portion.

Committee B-2 accordingly recommends that the revised Methods, which are appended to this report,[2] be approved and published as tentative for a year.

The committee recommends that the Tentative Methods for Battery Assay of Copper (B 34 – 19 T)[3] and the Tentative Methods for Chemical Analysis of Pig Lead (B 35 – 19 T)[4] be adopted by letter ballot of the Society as standard, after proper changes in style to conform to other A.S.T.M. methods.

The committee further recommends that the Method for Analysis of Spelter, which is now included in the Standard Specifications for Spelter (B 6 – 18)[5] be given a new serial number and published separately under methods of analysis, after rewriting to conform to the style of other A.S.T.M. methods; also that footnote 2, page 441, 1918 Book of A.S.T.M. Standards, be amplified as follows:

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XIX, Part I, p. 509 (1919).

[2] See p. 589.—ED.

[3] *Proceedings*, Am. Soc. Test. Mats., Vol. XIX, Part I, p. 517 (1919).

[4] *Ibid.*, p. 523.

[5] 1918 Book of A.S.T.M. Standards.

"If the solution is heated, or if time is not allowed for the action of the acid to cease completely, small amounts of cadmium may pass into the solution and be lost."

The committee understands that this recommendation, if approved, cannot be put into effect until the next edition of the Book of Standards is printed.

Mr. Jesse L. Jones, Chairman of Sub-Committee VIII, will furnish Sub-Committee VII with methods of analysis of aluminum to be submitted by members of this sub-committee in connection with recommended specifications for aluminum. Mr. Jones has already submitted an outline of method for pure aluminum, and this will be considered together with the other methods to be received.

Sub-Committee VIII on Aluminum and Aluminum Alloys.—Mr. Jesse L. Jones, chairman, presented Tentative Specifications for Aluminum for Use in the Manufacture of Iron and Steel, which are appended hereto,[1] with the recommendation that they be accepted for publication as tentative. These specifications cover two grades of Virgin and four grades of Secondary Aluminum. They are the work of a special sub-committee composed of members of Committee A-1 on Steel, Messrs. Speller, Sargent, Buck, Uhler and Aupperle; and members of Committee B-2, Messrs. Blough, T. J. Johnson, Pannell, Brile and Jones.

A complete revision of the Tentative Specifications for Aluminum Ingots for Remelting and for Rolling (B 24 - 19 T)[2] has been made. The main changes are that, instead of two grades containing 99 and 98 per cent aluminum respectively, three grades are now proposed containing a minimum of 99.5, 99.0, and 98 per cent aluminum. The new grade 99.5 per cent was added to meet the demands of the Bureau of Aircraft Production and the manufacturers of electrical apparatus. Sections are added to guard against the addition of scrap material. The section on Sampling is made more practical, but the sampling by heats was retained at the request of the Bureau of Aircraft Production. The committee recommends that the revised specifications be published as tentative.

The committee also recommends that the Tentative Specifications for Aluminum Sheet (B 25 - 19 T)[1] and the Tentative Specifications for Light Aluminum Casting Alloys (B 26 - 19 T)[2] remain tentative for another year.

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[1] See p. 586.—Ed.

[2] *Proceedings*, Am. Soc. Test. Mats., Vol. XIX, Part I, p. 473 (1919).

Sub-Committee IX on Nomenclature.—In February, 1919, Committee B-2 appointed a Sub-Committee IX on Nomenclature of Alloys. Dr. George K. Burgess was the first chairman. He subsequently resigned, and Mr. W. B. Price was chosen chairman. Three meetings of this sub-committee have been held since that date. The sub-committee has given careful consideration to the question of the Nomenclature of Non-Ferrous Alloys, and recommends that wherever possible the commercial names which have become established by long usage, such as Brass, Bronze and Cupro-Nickel, should be retained.

At the last meeting of the sub-committee, held November 17, 1919, at Washington, D. C., it was voted that the sub-committee is in sympathy with the report of the Nomenclature Committee of the British Institute of Metals[3] and requests that the sub-committee's Report of Progress be submitted to the British Institute for criticism, expressing the desire to cooperate with them. It was further voted that the former commercial names, such as Manganese or Aluminum Bronze, be placed in brackets beside the systematic name. The sub-committee also recommends that a list of all trade names, together with their chemical composition, be compiled and classified under their respective groups. While it is customary (in this country) to speak of Bronze as a Copper-Tin alloy and Brass as a Copper-Zinc alloy, in the interests of harmony, and the possible international adoption of a systematic Nomenclature, the sub-committee has decided to adopt the systematic names proposed by the British Institute of Metals, Tin-Copper, Zinc-Copper, etc. The sub-committee also believes that the classification of Brass should be sub-divided into two or more groups.

In this connection the question of classification by color as well as chemical composition has been very carefully considered, due to the fact that Brass and Bronze are generally judged first by color.

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[1] See p. 546.

[2] See p. 549.

[3] *Journal*, British Inst. Metals, Vol. XI (1914), p. 45.

The proposed Nomenclature of Non-Ferrous Alloys, including a Tentative Color Classification, follows:

NOMENCLATURE OF NON-FERROUS ALLOYS.

BRASS.

1. The term *Yellow Brass* shall be used for Zinc-Copper alloys only, containing from 63 to 80 per cent Copper and having a yellow or brass color.

EXAMPLE: *Composition of Alloy:* Zinc, 30 per cent; Copper, 70 per cent.
Systematic Name: Zinc-Copper.

2. The term *Red Brass* shall be used for Zinc-Copper Alloys only, containing more than 80 per cent copper, in which the color varies from a golden to a copper red.

EXAMPLE: *Composition of Alloy:* Zinc, 15 per cent; Copper, 85 per cent.
Systematic Name: Zinc-Copper.

3. The term *Yellow-Red Brass* shall be used for Zinc-Copper alloys only, containing from 55 to 63 per cent copper, in which range the Brass has a yellowish red color.

EXAMPLE: *Composition of Alloy:* Zinc, 40 per cent; Copper, 60 per cent.
Systematic Name: Zinc-Copper.

4. *Lead Brass.*—Brass containing more than 0.50 per cent of Lead shall be known as Lead Yellow, Red, or Yellow-Red Brass, according to the percentage of Copper it contains.

EXAMPLE: Lead-Yellow Brass.
Composition of Alloy: Lead, 1 per cent; Zinc, 33 per cent; Copper, 66 per cent.
Systematic Name: Lead-Zinc-Copper.

5. *Tin Brass.*—Brass containing more than 0.25 per cent Tin shall be known as Tin Yellow, Red or Yellow-Red Brass, according to the percentage of Copper it contains.

EXAMPLE: Tin-Yellow-Red Brass.
Composition of Alloy: Tin 0.50 per cent; Zinc, 39.50 per cent; Copper, 60 per cent.
Systematic Name: Tin-Zinc-Copper.

6. In cases where other metals are added, these shall be designated by the use of the proper prefix or prefixes:

EXAMPLE: Manganese-Tin-Yellow-Red-Brass.
Composition of Alloy: Manganese, 0.50 per cent; Tin, 1 per cent; Zinc, 38.50 per cent; Copper, 60 per cent.
Systematic Name: Manganese-Tin-Zinc-Copper.

BRONZE.

7. The term *Bronze* shall be used for Tin-Copper Alloys only, containing over 50 per cent Copper. In cases where other metals are added these shall be designated by the proper prefix or prefixes:

EXAMPLE: Aluminum-Bronze.
Composition of Alloy: Aluminum, 3 per cent; Tin, 5 per cent; Copper, 92 per cent.
Systematic Name: Aluminum-Tin-Copper.

CUPRO-NICKEL.

8. The term *Cupro-Nickel* shall be used for Nickel-Copper Alloys in which Copper predominates. In cases where other metals are added these shall be designated by the proper prefix or prefixes:

EXAMPLE: Iron-Manganese-Cupro-Nickel.
Composition of Alloy: Iron, 1.5 per cent; Manganese, 2 per cent; Nickel, 29.5 per cent; Copper, 67 per cent.
Systematic Name: Iron-Manganese-Nickel-Copper.

NICKELENE.

9. The term *Nickelene* shall be used for Nickel-Zinc-Copper Alloys only. In cases where other metals are added these shall be designated by the proper prefix or prefixes:

EXAMPLE: Lead-Nickelene.
Composition of Alloy: Lead, 1 per cent; Nickel, 5 per cent, Zinc, 31.50 per cent; Copper, 62.50 per cent.
Systematic Name: Lead-Nickel-Zinc-Copper.

In addition to the name "Nickelene" for Nickel-Zinc-Copper alloys, the name "Nickeloids" and "Nicuzin" have been proposed.

The nomenclature suggested contemplates the naming of non-ferrous alloys so as to indicate the fundamental elements in the composition of the alloy involved. The following specific points are observed:

(*a*) The last word of each name is "alloy" unless the alloy in question is a bronze or a brass, or other commercial name which has been established by long usage, as Cupro nickel, etc., as heretofore defined, in which case the last word of the name is either "Bronze," "Brass" or "Cupro-Nickel," etc. (whichever is appropriate).

(*b*) The names are so given as to indicate the relative contents of the various elements—the element with the smallest content hence is used to commence the name of the alloy; thus an alloy bearing a name "Tin-Antimony-Lead Alloy" (Magnolia metal, approximate composition: lead 77 per cent, antimony 17 per cent, tin 6 per cent) means that lead is present in the largest amount; next to lead, the antimony content is the largest and that next to antimony the tin content is the largest.

(*c*) No account is taken in the name suggested of elements which are present in amounts of 1 per cent or less or when the elements may be present as an impurity, but do not constitute a normal or *fundamental* part of the ally. The exception to this is in the case of those elements present in very small quantities (less than 1 per cent) which have been added to the alloy for the purpose of *markedly* influencing the properties of the resultant alloy; such as in the use of phosphorus or vanadium, as a deoxidizer; or, the use of small quantities of lead to improve machining qualities in wrought brass or bronze; these exceptions, however, do not include the use in small quantities (less than 1 per cent) of elements for the purpose of improving some particular property of an alloy, such as the addition of a small amount of aluminum to "Cast Naval Brass" to promote fluidity in pouring.

(*d*) For the time being, so as to permit a comprehension of the intent and meaning of the proposed new nomenclature, the alloys newly named in accordance with the foregoing should have in parenthesis, after their new name, their former name.

Committee B-2, therefore, requests the Executive Committee of the Society to transmit this report of progress to the British Institute of Metals in order to bring it to their attention for criticism and comment.

The analysis of the letter ballot vote of the committee is as follows:

Items.	Affirmative.	Negative.	Not Voting.
I. PROPOSED REVISIONS IN STANDARD.			
1. For Copper Bars for Locomotive Staybolts (B 12-18)	----	----	----
II. PROPOSED REVISIONS IN TENTATIVE STANDARDS.			
2. For Lead (B 29 - 19 T)	35	0	10
3. For Aluminum Ingots for Remelting and for Rolling (B 24-19 T)	28	0	17
4. Methods for Chemical Analysis of Alloys of Lead, Tin, Antimony and Copper (B 18 - 17 T)	35	0	10
III. PROPOSED NEW TENTATIVE STANDARDS.			
5. For Sheet High Brass	30	0	15
6. For Aluminum for Use in the Manufacture of Iron and Steel	28	0	17
IV. TENTATIVE STANDARDS TO BE ADOPTED AS STANDARD.			
7. Methods for Battery Assay of Copper (B 34 - 19 T)	35	0	10
8. Methods for Chemical Analysis of Pig Lead (B 35 - 19 T)	36	0	9
9. Recommendation with Respect to Separate Publication of Methods of Analysis of Spelter	34	0	11

This report has been submitted to letter ballot of the committee, which consists of 45 members, of whom 40 have voted affirmatively, 1 negatively, and 4 have refrained from voting.

Respectfully submitted on behalf of the committee,

WM. CAMPBELL,
Chairman.

EDITORIAL NOTE.

The Tentative Methods for Battery Assay of Copper and the Tentative Methods for Chemical Analysis of Pig Lead, referred to in this report, were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1920 and appear in the supplementary pamphlet of A.S.T.M. Standards Adopted in 1920.

The proposed revision of the Standard Specifications for Copper Bars for Locomotive Staybolts was accepted for publication as tentative and appears in page 816.

The revisions recommended in the Tentative Specifications for Lead, in the Tentative Specifications for Aluminum Ingots for Remelting and for Rolling, and in the Tentative Methods for Chemical Analysis of Alloys of Lead, Tin, Antimony and Copper were accepted. The specifications as thus revised appear on pages 554, 543 and 589, respectively.

The proposed Tentative Specifications for Sheet High Brass, and the proposed Tentative Specifications for Aluminum for Use in the Manufacture of Iron and Steel were accepted for publication as tentative and appear on pages 580–588.

APPENDIX.

PROPOSED REVISIONS IN STANDARDS AND TENTATIVE STANDARDS FOR NON-FERROUS METALS.

No. 1.—Proposed Revisions in the Tentative Specifications for Lead (B 29 - 19 T).[1]

1. Change the title from "Tentative Specifications for Lead," to read "Tentative Specifications for Pig Lead."

2. *Section 1.*—Change to read as follows by the addition of the italicized words:

"Virgin Lead is lead made from ore or similar raw material by direct processes of reduction and refining, and not produced from reworked metal, *and is termed Pig Lead.*"

3. *Section 4.*—Change to read as follows by the addition of the italicized words and figures and the omissions of the figures in brackets:

"Corroding Lead (Grade I) shall conform to the following requirements as to chemical composition:

Silver..................	not over		0.0015	per cent
Copper..................	" "	[0.001]	*0.0015*	"
Copper and Silver together..	" "		*0.0025*	"
Arsenic..................	" "	[0.001]	*0.0015*	"
Antimony and Tin together	" "	[0.0075]	*0.0095*	"
Zinc..................	" "		0.001	"
Iron..................	" "	[0.0015]	*0.002*	"
Bismuth..................	" "		0.05	"
Lead (by difference).............		[99.9365]	*99.9335*	"

4. *Section 5.*—Change to read as follows by the addition of the italicized figures and footnote and the omission of the figures in brackets:

"Chemical Lead (Grade II) shall conform to the following requirements as to chemical composition:[1]

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[1] *This composition represents present requirements in the United States.*

Copper	[0.05 – 0.10] *0.04 – 0.10*		per cent
Bismuth	not over	0.005	"
Total Impurities other than Copper	" "	0.05	"

5. *Section 6 (b)*.—(*a*) Change to read as follows by the addition of the italicized figures and the omission of the figures in brackets:

(*b*) Soft Missouri Lead:

Silver	not over		0.002	per cent
Copper	" "	[0.05]	*0.04*	"
Arsenic, Antimony and Tin together	" "		0.015	"
Bismuth	" "		0.005	"
Iron	" "		0.005	"
Zinc	" "		0.002	"
Lead (by difference)		[99.921]	*99.931*	"

(*b*) Change the footnote relating to Section 6 (*b*) to read as follows by the omission of the words in brackets:

"Soft Missouri Lead is a trade name used to cover soft undesilverized lead [in general]."

No. 2.—Proposed Revisions in the Standard Specifications for Copper Bars for Locomotive Staybolts (B 12 – 18).[1]

Section 9.—Change to read as follows by the addition of the figures in italics and the omission of the figures in brackets:

"The bars shall be truly round within 0.01 in., and shall not vary more than [0.005] *0.01* in. above nor more than [0.01] *0.005* in. below the specified size."

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[1] 1918 Book of A.S.T.M. Standards.

DISCUSSION.

Mr. E. L. Lasier (*presented in written form*).—The Bureau of Construction and Repair of the Navy Department, as a member of Committee B-2 and in connection with its vote on the report of that committee, has expressed itself as not being in favor of the portion of the report dealing with the work of Sub-Committee IX on the nomenclature of the non-ferrous alloys. **Mr. Lasier.**

I am not speaking officially on behalf of the Bureau of Construction and Repair. My personal opinions and present convictions may, however, be of interest since they have been, I believe, reflected by the action of the Bureau as a member of Committee B-2 and of Sub-Committee IX thereof. In fact this discussion is submitted indirectly as the result of a request of the chairman of Committee B-2.

The question of the nomenclature of the non-ferrous alloys is one in which I have been and am very much interested, an interest dating back prior to the appointment of the Bureau of Construction and Repair as a member of Sub-Committee IX of Committee B-2. When the Bureau of Construction and Repair, soon after its appointment to Sub-Committee IX, was asked by the chairman of that sub-committee to submit suggestions relative to a proposed system of nomenclature, a system was proposed which, without realizing it at the time, falls closely in line with that suggested several years ago in the first report of the committee on the nomenclature of alloys, of which Dr. Walter Rosenhain was chairman, of the British Institute of Metals.

I am in entire sympathy with certain phases of the proposed system of nomenclature as set forth in the report of Committee B-2. I approve of a scheme of nomenclature similar in general to that reported by the nomenclature committee of the British Institute of Metals[1] contemplating the naming of the non-ferrous alloys so as to indicate the fundamental elements of the com-

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[1] *Journal*, British Institute of Metals, Vol. XI, p. 45 (1914).

Mr. Lasier. position involved; of carrying in brackets or parentheses, for the time being, the former commercial names, such as "manganese bronze" or "aluminum bronze", etc., beside the systematic name,—assuming that a systematic scheme of nomenclature based upon the composition of the alloy involved, is adopted; and of the compilation for purposes of information, of a list of non-ferrous alloys which will classify the more commonly known alloys under the proposed systematic name. In brief, the four "specific points" enumerated under (*a*), (*b*), (*c*) and (*d*) on pages 240–241 of the report of Committee B-2 impress me as affording a satisfactory basis for the ultimate adoption of a logical and systematic method of nomenclature for the non-ferrous alloys, except that I would suggest that in lieu of using a term such as "cupro", the full name "copper" be used.

It is my clear recollection that in substance the proposals just stated were adopted by Sub-Committee IX at the meeting of that sub-committee held November 17, 1919, referred to in the report of Committee B-2, and that no other proposed nomenclature (such as one based upon the color classification, etc.) has been approved by Sub-Committee IX, as might be inferred from pages 239 and 240 of the report.

I am not in favor of any color classification of non-ferrous alloys or any classification which involves the use of such terms as "nickelene", "nickeloids", "nicuzin", etc. Moreover, the consideration of such a classification or scheme of nomenclature is, it would appear, at direct variance with the scheme approved by Sub-Committee IX, which is based upon the systematic naming of non-ferrous alloys according to the fundamental elements in the composition of the alloy involved. It is self-evident that terms such as "nickelene", "nickeloids", "nicuzin", do not in any way, and terms such as "cupro-nickel" only do in part, "contemplate the naming of non-ferrous alloys so as to indicate the fundamental elements of the composition of the alloy involved". (See page 240, next to the last paragraph, report of Committee B-2). The inference from pages 239 and 240 of the report of Committee B-2 is, however, that Committee B-2 and Sub-Committee IX thereof, are seriously considering, in fact in a tentative way are advocating to the Society, a color classification scheme, and a system of nomen-

Mr. Lasier.

clature involving the use of such terms as "nickelene", "nickeloids", "nicuzin", etc.

This discussion is offered in an effort to assist, rather than with any intention of obstructing, the efforts of Sub-Committee IX of Committee B-2 and of the Society toward eventually adopting a satisfactory method of nomenclature for the non-ferrous alloys.

Mr. Price.

MR. WILLIAM B. PRICE, *Chairman, Sub-Committee IX, Committee B-2* (*presented in written form*).—The remarks of Mr. Lasier may be considered as a minority report of Sub-Committee IX on the Nomenclature of Non-Ferrous Alloys.

Mr. Lasier's statements that, "The inference from pages 239 and 240 of the Report of Committee B-2 is, however, that Committee B-2 and Sub-Committee IX thereof, are seriously considering, in fact in a tentative way are advocating to the Society, a color classification scheme, and a system of nomenclature involving the use of such terms as 'nickelene', 'nickeloids', 'nicuzin', etc." would imply that Sub-Committee IX is advocating a tentative color classification scheme; whereas it is expressly stated on page 241, that "Committee B-2, therefore, requests the Executive Committee of the Society to transmit this *report of progress* to the British Institute of Metals in order to bring it to their attention for criticism and comment."

This statement clearly indicates that this is a report of progress and not a tentative color classification scheme as implied by Mr. Lasier. This report of progress is published in order that the committee may obtain from other societies and individuals interested, criticism and comment, as well as that which we expect to obtain from the British Institute of Metals.

The Bureau of Construction and Repair of the Navy Department, in the person of Mr. Lasier, have consistently opposed color classification, the use of commercial terms, such as "cupro-nickel", and other classifications involving such terms as "nickelene", "nicekloids", "nicuzin", etc.

It is stated in the committee's report, page 238, "In this connection the question of classification by color as well as chemical composition has been very carefully considered, due to the fact that brass and bronze are generally judged first by color."

Mr. Price. It is the opinion of the majority of the sub-committee that the color classification should be considered along with other suggested classifications. This is indicated by the vote of the eleven members of the sub-committee on this report of progress, which was as follows: nine affirmative, one negative, one not voting.

The sub-committee has not, however, suggested to Committee B-2 that its work be proposed as tentative and it is not ready to recommend any definite action. Its progress report is made entirely with the idea of securing a general expression of opinion and discussion.

Mr. Pannell. MR. E. V. PANNELL.—Referring to the proposed Tentative Specifications for Aluminum Ingots for Remelting and for Rolling,[1] were the present standards permanent, the inclusion of a grade of aluminum 99.5 per cent pure would be open to criticism. The fact that such a figure is given in print might convey the impression that the art of electrolyzing aluminum has advanced to a stage where this is a reasonable commercial purity. Unfortunately this is not the case and the purity mentioned must of necessity form a very small proportion of a producer's output. Under the very best possible conditions, more than nine tons of lower purity metal must be produced and sold before one ton of 99.5-per-cent grade is available. It is furthermore not yet demonstrated that any wide demand exists which cannot be satisfied by 99 or 98-per-cent metal.

Mr. Campbell. MR. WILLIAM CAMPBELL, *Chairman of Committee B-2* (*by letter*).—The following criticisms of certain of the standard and tentative specifications for non-ferrous metals and alloys published by the Society have been received from the Engineering Division of the Aircraft Service, U. S. War Department. It is suggested that they be published as discussion in the Proceedings:

Tentative Specifications for Brass Ingot Metal for Sand Castings (*B 30 – 19 T*).—We use only your alloy grade No. 2 (85–5–5–5), but our total impurities maximum is 0.25 per cent, which would be easily met, for first grade materials only are used. The composition of our yellow brass varies slightly from the composition of B-32 as we do not allow more than 65 per cent copper, nor any tin. We are considering changing our specifi-

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[1] See p. 543.—ED.

Mr. Campbell.

cation, however, to allow the maximum impurity content of 1.25 per cent, to include tin and aluminum as we find that several foundries want to use a small amount of tin.

Tentative Specifications for Bronze Bearing Metal in Ingot Form (B 31 – 19 T).—Phosphor bronzes of the following composition gave good results as the liners for babbitted bearings in the Liberty motor:

Copper, per cent.	Tin, per cent.	Lead, per cent.	Zinc, per cent.	Iron, per cent.	Phosphorus, per cent.
77.87	9.56	10.20	2.23	0.12	0.019
89.37	6.08	2.02	2.40	0.12	0.010
79.88	9.52	10.07	0.29	0.22	0.015
78.92	9.75	10.17	0.93	0.21	0.021

Their service was good despite the fact that our specification calls for:

Copper, per cent	79.0 – 81.0
Tin, per cent	9.0 – 11.0
Lead, per cent	9.0 – 11.0
Phosphorus, per cent	0.1 – 0.3
Total impurities	0.25

We should like to keep phosphorus less than 0.3 per cent. We believe it would be well to specify that bearing bronzes be free from porosity and oxide films.

Tentative Specifications for Solder Metal (B 32 – 19 T).—The Air Service has been considering changing the specification for solder by lowering the tin content, but we do not have enough data at the present time to make any definite recommendation, except for certain particular cases where we are using a solder with a minimum tin content of 45 per cent and are experiencing no trouble.

Tentative Specifications for White Metal Bearing Alloys (B 23 – 18 T).—Air Service specifications for Babbitt Metal specify: tin, 91 per cent; copper, 4.5 per cent; antimony, 4.5 per cent; lead, 0.2 per cent, maximum. It is assured that we must have antimony and copper limits between 4 and 5 per cent. We are not sure, however, of the tin and lead content.

The analyses of babbitts which gave satisfactory service

Mr. Campbell. under heavy duty in the Liberty motor crankshaft bearings and connecting rod bearings in one instance are as follows:

TIN, PER CENT.	ANTIMONY, PER CENT.	COPPER, PER CENT.	LEAD, PER CENT.	IRON, PER CENT.	ZINC, PER CENT.	ARSENIC, PER CENT.
90.24	4.44	4.47	1.85	Trace	None	None
90.88	4.49	4.45	0.18	Trace	None	None
87.63	4.42	5.24	2.52	0.19	None	None
88.04	4.52	4.38	2.87	0.19	None	None

The lead content as shown by these analyses is higher than we specify, but the service was satisfactory. All these babbitts will permit of a very thin lining.

We believe the impurities limits for arsenic and aluminum, Specification B 23, are satisfactory.

Standard Specifications for Manganese Bronze Ingots for Sand Castings (B 7 – 14).—We could not work to any such wide limits for copper and zinc as you propose. We prefer our specification which runs as follows:

Copper, per cent	56.0 to 60.0
Zinc, per cent	37.0 to 41.0
Lead (maximum), per cent	0.15
Hardening constituents (tin, iron, manganese, aluminum) (maximum), per cent	3.0

Nevertheless, we have had good results with the lead content as high as 0.54 per cent.

We favor your 20 per cent elongation rather than our 15 per cent.

The Webbert test specimen casting is good.

We should add to your specification a clause requiring that the test specimen shall receive any heat treatment to which the casting is subjected, in order to prevent test bars from being heat treated while the main casting remains in the cast condition.

Standard Specifications for the Alloy: Copper 88 per cent; tin, 10 per cent; zinc, 2 per cent (B 10 – 18).—Impurity limits should be required in your specifications. Iron, lead, manganese, etc., should not run over 0.50 per cent. We favor the substitution of the 88–8–4 alloy. An elongation of 14 per cent is lower than we allow.

REPORT OF COMMITTEE C-1
ON
CEMENT.

Committee C-1 reports that its activities this past year have been largely centralized in the endeavor to secure one generally accepted "Specifications and Tests for Portland Cement."

The present specifications of the American Society for Testing Materials for Portland cement became effective on January 1, 1917. There was an opinion among some, however, that the specification for the "fineness" should be different and for this reason the U. S. Government Departmental Committee concluded to specify a fineness with a permissible 2 per cent less residue on the No. 200 sieve than that permitted by the American Society for Testing Materials specifications. Their specification was finally made by the Government Departmental Committee to become effective January 1, 1921.

Committee C-1 felt that, if a conference could be held between representatives of the American Society for Testing Materials and the Government Departmental Committee to consider the difference of opinion, the question could be thoroughly discussed and understood. So, finally, the Government Departmental Committee and the Executive Committee of the Society each appointed a special committee and on May 10 a conference was held at the Bureau of Standards, Washington, D. C. This conference entered fully into the effect of fineness on the strength of cement and concrete and also into the cost of producing additional percentages of fineness. The results of the conference were most satisfactory.

Committee C-1 would now ask the Society to withdraw from the Standard Specifications and Tests for Portland Cement (C 9 - 17)[1] Section 36 on Permissible Variation in Fineness, which reads:

> "A permissible variation of 1 will be allowed, and all results in excess of the specified limit but within this permissible variation shall be reported as 22 per cent.",

such action to become effective on January 1, 1921. The committee would ask that the succeeding sections of the specifications be renumbered accordingly.

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[1] 1918 Book of A.S.T.M. Standards.

It should be said that the A.S.T.M. Standard Specifications and Tests for Portland Cement have been accepted by the American Engineering Standards Committee as Tentative American Standards. It would seem that the Standards Committee would soon be able to accept these specifications as the American Standard for Portland cement, and for the first time, after over 20 years of conscientious study and effort, cement will be made and purchased under one specification.

While the present specifications are evidently producing satisfactory results, Committee C-1 does not intend to cease studying cement or to neglect to investigate any phases of the testing which may be used to produce even a better product or more satisfactory tests. For these reasons the several sub-committees are being asked to continue their research work. Some of these sub-committees have active problems now under consideration, notably the sub-committee on "Strength" which hopes soon to make a positive recommendation on the Tentative Specifications and Tests for Compressive Strength of Portland-Cement Mortars.[1] In this connection it should be reported that this sub-committee will soon present for consideration and trial uses a new type of small compression machine.

In conclusion, Committee C-1 further recommends that the Tentative Specifications and Tests for Compressive Strength of Portland-Cement Mortars be continued as tentative.

This report has been submitted to letter ballot of the committee, which consists of 60 members, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

RUSSELL S. GREENMAN,
Chairman.

P. H. BATES,
Secretary.

EDITORIAL NOTE.

The proposed revision of the Standard Specifications and Tests for Portland Cement, referred to in this report, and the further revision proposed by the committee at the annual meeting (see Summary of the Proceedings, page 27) were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1920, to become effective on January 1, 1921.

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[1] See p. 599.

REPORT OF COMMITTEE C-2
ON
REINFORCED CONCRETE.

In its annual report last year, Committee C-2 on Reinforced Concrete referred to the favorable action of the Executive Committee of the Society upon the committee's recommendation made in August, 1917, that the American Society of Civil Engineers, the American Railway Engineering Association, the American Concrete Institute and the Portland Cement Association be invited to form with our Society a Joint Committee for the purpose of preparing specifications for reinforced concrete, these four organizations, with the A.S.T.M., having cooperated in the work of the former Joint Committee on Concrete and Reinforced Concrete. The Executive Committee extended invitations to these four organizations, and by November 22, 1919, acceptances had been received from all of them. The five cooperating bodies agreed to appoint five representatives each to the Joint Committee.

The Executive Committee accordingly issued a call to the 25 representatives thus appointed, to attend an organization meeting on February 11, 1920. There were present at this meeting, 18 of the 25 representatives, this Society being represented by Messrs. Richard L. Humphrey, Henry H. Quimby, Leon S. Moisseiff and Albert T. Goldbeck (by E. B. Smith). The meeting was held in the Engineer's Club of Philadelphia and was called to order by George S. Webster, Vice-President of the American Society for Testing Materials, who acted as the Temporary Chairman, while C. L. Warwick, the Secretary of the Society, acted as the Temporary Secretary.

Reference is made in the annual report of the Executive Committee to the preliminary details of organization.

The personnel of the Joint Committee on Standard Specifications for Concrete and Reinforced Concrete follows:

AMERICAN SOCIETY OF CIVIL ENGINEERS

Rudolph P. Miller, *Chairman*,
William K. Hatt,
A. E. Lindau,
W. A. Slater,
Sanford E. Thompson.

AMERICAN SOCIETY FOR TESTING MATERIALS

Richard L. Humphrey, *Chairman*,
Albert T. Goldbeck,
Edward E. Hughes,
Leon S. Moisseiff,
Henry H. Quimby.

AMERICAN RAILWAY ENGINEERING ASSOCIATION

J. J. Yates, *Chairman*,
George E. Boyd,
Frederick E. Schall,
C. C. Westfall,
H. T. Welty.

AMERICAN CONCRETE INSTITUTE

S. C. Hollister, *Chairman*,
Robert W. Lesley,
Arthur R. Lord,
E. J. Moore,
Leonard C. Wason.

PORTLAND CEMENT ASSOCIATION

Frederick W. Kelley, *Chairman*,
Duff A. Abrams,
Ernest Ashton,
Edward D. Boyer,
J. H. Libberton.

The Conference adopted as its name "Joint Committee on Standard Specifications for Concrete and Reinforced Concrete."

The following officers were elected:

Chairman: Richard L. Humphrey.
Vice-Chairman: J. J. Yates.
Secretary-Treasurer: Duff A. Abrams.

An Executive Committee was appointed consisting of the three officers and the chairman of the group committees not already represented by the officers, namely:

Rudolph P. Miller and S. C. Hollister.

By-laws for the government of the Joint Committee were adopted, which are appended to this report.

Sub-committees were appointed as follows:

1. *Materials (other than Reinforcing).*
   - Albert T. Goldbeck, *Chairman*,
   - Duff A. Abrams,
   - J. H. Libberton,
   - Sanford E. Thompson,
   - J. J. Yates.

2. *Metal Reinforcement.*
   - J. J. Yates, *Chairman*,
   - Edward E. Hughes,
   - A. E. Lindau.

3. *Proportioning and Mixing.*
   - W. A. Slater, *Chairman*,
   - Duff A. Abrams,
   - Ernest Ashton,
   - George E. Boyd,
   - Henry H. Quimby.

4. *Forms and Placing.*
   - George E. Boyd, *Chairman*,
   - Edward D. Boyer,
   - E. J. Moore,
   - Frederick E. Schall,
   - Leonard C. Wason.

5. *Design.*
   - S. C. Hollister, *Chairman*,
   - William K. Hatt,
   - A. E. Lindau,
   - Arthur R. Lord,
   - E. J. Moore,
   - W. A. Slater,
   - H. T. Welty.

6. *Details of Construction and Fireproofing.*

Rudolph P. Miller, *Chairman*,
William K. Hatt,
Arthur R. Lord,
Leon S. Moisseiff,
C. C. Westfall.

7. *Waterproofing and Protective Treatment.*

Frederick W. Kelley, *Chairman*,
Albert T. Goldbeck,
S. C. Hollister,
Robert W. Lesley,
C. C. Westfall.

8. *Surface Finish.*

Henry H. Quimby, *Chairman*,
Edward D. Boyer,
J. H. Libberton,
Leonard C. Wason,
H. T. Welty.

9. *Form of Specification.*

Richard L. Humphrey, *Chairman*,
Duff A. Abrams,
George E. Boyd,
Albert T. Goldbeck,
S. C. Hollister,
Frederick W. Kelley,
Rudolph P. Miller,
Henry H. Quimby,
W. A. Slater,
J. J. Yates.

The Joint Committee will meet at Asbury Park, N. J., during the Annual Meeting of the Society.

Committee C-2 at its meeting on May 12, 1920, after careful consideration of the situation, decided to wait until the Joint Committee had made sufficient progress in its work as would indicate along what lines Committee C-2 could assist in the work of preparing specifications for concrete and reinforced concrete.

The following committee was, however, appointed on "Rules for Inspection of Reinforced Concrete":

Duff A. Abrams, *Chairman*,
Lewis J. Johnson,
S. C. Hollister,
Leon S. Moisseiff,
Henry C. Turner.

This report has been submitted to letter ballot of the committee, which consists of 18 members, of whom 13 have voted affirmatively, 2 negatively, and 3 have refrained from voting.

Respectfully submitted on behalf of the committee,

RICHARD L. HUMPHREY,
Chairman.

SAMUEL T. WAGNER,
Secretary.

APPENDIX.

BY-LAWS
OF THE JOINT COMMITTEE ON STANDARD SPECIFICATIONS FOR CONCRETE AND REINFORCED CONCRETE

Adopted February 11, 1920.

ARTICLE I.

OBJECT.

SECTION 1. The object of the Joint Committee shall be the preparation of standard specifications for concrete and reinforced concrete.

ARTICLE II.

MEMBERS.

SECTION 1. The membership of the Joint Committee shall consist of five delegated representatives from each of the following five societies:

American Society of Civil Engineers;
American Railway Engineering Association;
American Concrete Institute;
Portland Cement Association;
American Society for Testing Materials.

SEC. 2. A member of the Joint Committee shall be authorized to delegate any desired individual as his proxy at a meeting of the Joint Committee or any of its committees, with voting power or without voting power as specified; but no individual shall have more than one vote at a meeting of the Joint Committee or any of its committees.

ARTICLE III.

OFFICERS AND THEIR ELECTION.

SECTION 1. The officers of the Joint Committee shall be a Chairman, a Vice-Chairman and a Secretary-Treasurer, and their terms of office shall be two years.

SEC. 2. The officers shall be elected by written ballot by the Joint Committee at a meeting called for that purpose. A majority vote of those present and voting shall be necessary for election.

SEC. 3. There shall be an Executive Committee composed of the officers of the Joint Committee and of the chairman of each Society group not represented by the officers.

SEC. 4. The Executive Committee shall have power to fill any vacancies occurring among the officers by death, resignation or otherwise, for the remainder of the unexpired portion of the term of office.

ARTICLE IV.

DUTIES OF OFFICERS AND EXECUTIVE COMMITTEE.

SECTION 1. *Chairman.* It shall be the duty of the Chairman to call and preside at all meetings of the Joint Committee, and he shall be ex-officio a member of all committees and chairman of the Executive Committee.

SEC. 2. *Vice-Chairman.* The Vice-Chairman shall, in the event of disability or absence of the Chairman, perform all the duties of the Chairman.

SEC. 3. *Executive Committee.* It shall be the duty of the Executive Committee to appoint such committees as may be necessary to carry out the work of the Joint Committee, to supervise the disbursement of all funds in the charge of the Joint Committee, and to perform such duties as may be delegated to it by the Joint Committee.

SEC. 4. *Secretary-Treasurer.* The Secretary-Treasurer shall be charged with such duties as the Joint Committee or the Executive Committee may determine.

ARTICLE V.

MEETINGS.

SECTION 1. The Joint Committee shall meet at least once a year, the time and place of such meetings to be fixed by the Executive Committee.

SEC. 2. Special meetings may be called by the Executive Committee at its discretion.

SEC. 3. A majority of the Joint Committee shall constitute a quorum.

ARTICLE VI.

ORDER OF BUSINESS.

SECTION 1. The order of business shall be as follows:

1. Roll call;
2. Minutes of last meeting;
3. Reports of officers;
4. Reports of committees;
5. Unfinished business;
6. New business.

ARTICLE VII.

FUNDS.

SECTION 1. All funds shall be in the hands of the Secretary-Treasurer, and shall be disbursed only on order of the Executive Committee, on vouchers signed by the Chairman and the Secretary-Treasurer.

SEC. 2. The funds contributed to the five Societies shall be applied only to the payment of expenses for stationery, postage and clerical work, including duplication of minutes and reports.

SEC. 3. Expenditures shall not exceed the amounts authorized by the five Societies, nor shall additional funds be solicited without the prior approval of the five Societies.

ARTICLE VIII.

LETTER BALLOTS.

SECTION 1. Reports of the Joint Committee and its committees shall be submitted to letter ballot of the members of the respective committees. Dissenting members of the committees shall have the right to present minority reports individually or jointly at the time at which the majority report is presented to the Joint Committee.

ARTICLE IX.

REPORT OF JOINT COMMITTEE.

SECTION 1. The Joint Committee shall not itself publish any reports, but shall submit its reports to the five Societies represented on the Joint Committee.

SEC. 2. The initial report of the Joint Committee shall be considered by each of the five Societies as a tentative report submitted for criticism and discussion, limited to not less than six months nor more than one year. Such discussions shall then be referred to the Joint Committee for its consideration in revising its report.

SEC. 3. It is understood that each cooperating body reserves the right to independent action on reports of the Joint Committee.

ARTICLE X.

LIFE OF JOINT COMMITTEE.

SECTION 1. The Joint Committee may be dissolved by joint action of the five Societies represented thereon; provided, however, that its existence shall not be terminated prior to the consideration of and final action on its final report by each of the five Societies, in order that the Joint Committee may be in a position to consider any criticisms of that report that may be made by any of the five Societies.

ARTICLE XI.

RULES OF ORDER.

SECTION 1. Robert's Rules of Order, Revised, shall govern the conduct of meetings of the Joint Committee and of its Committees where they are not in conflict with these By-Laws.

ARTICLE XII.

AMENDMENTS.

SECTION 1. These By-Laws may be amended by a two-thirds vote of those present at any meeting of the Joint Committee, notice of proposed amendments having been given in the call for such meeting.

REPORT OF COMMITTEE C-3

ON

BRICK.

Since the last annual meeting of the Society, Committee C-3 has held one meeting, at Columbus, O., February 19, 1920, at which the Tentative Specifications for Building Brick (C 21 – 19 T)[1] were considered. The only revision made in the specifications was to change the proposed standard size for building brick from $2\frac{1}{4}$ by $3\frac{7}{8}$ by 8 in. to $2\frac{1}{4}$ by $3\frac{3}{4}$ by 8 in.

This change was made for the purpose of conforming to the standard sizes adopted by the Common Brick Manufacturers' Association and other organizations.

The committee recommends that the Tentative Specifications for Building Brick, as thus revised, be referred to letter ballot of the Society for adoption as standard.

This report has been submitted to letter ballot of the committee, which consists of 16 members, of whom 13 have voted affirmatively, 1 negatively, and 2 have refrained from voting.

Respectfully submitted on behalf of the committee,

EDWARD ORTON, JR.,
Chairman.

A. V. BLEININGER,
Secretary.

EDITORIAL NOTE.

The proposed revision of the Tentative Specifications for Building Brick was accepted. The specifications, as thus revised, were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1920, and appear in the supplementary pamphlet of A.S.T.M. Standards Adopted in 1920.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XIX, Part I, p. 537 (1919).

REPORT OF COMMITTEE C-4
ON
CLAY AND CEMENT SEWER PIPE.

Since the last annual report was issued, Committee C-4 has held three meetings, at which were considered the reports of the several sub-committees. Minor modifications have been accepted by the committee as amendments to the tentative specifications for which the committee is responsible. These appear as an Appendix to this report. The adoption of these amendments by the Society is recommended.

The committee has by letter ballot agreed that the specifications for clay sewer pipe and for cement-concrete sewer pipe be presented to the Society as separate forms.

The committee is of the opinion that its work has proceeded sufficiently far to warrant the two separate specifications covering both classes of pipe, with the proposed amendments, being submitted to the Society for adoption as standard. It is proposed to continue the investigations of several sub-committees and to recommend to the Society, from time to time, the adoption of such further amendments in the specifications as may become desirable.

It is therefore recommended that the Tentative Specifications for Clay Sewer Pipe (C 13 - 18 T), and the Tentative Specifications for Cement-Concrete Sewer Pipe (C 14 - 19 T), with the revisions herewith presented, be submitted to letter ballot of the Society for adoption as standard.

It is further recommended that the Tentative Specifications for Required Safe Crushing Strengths of Sewer Pipe to Carry Loads from Ditch Filling (C 15 - 17 T)[1] be continued as tentative for another year.

This report, including the attached appendix, has been submitted to letter ballot of the committee, which consists of 24 members, of whom 15 have voted affirmatively, 5 negatively, and 4 have refrained from voting.

Respectfully submitted on behalf of the committee,

RUDOLPH HERING,
Chairman.

G. T. HAMMOND,
Secretary.

A. J. PROVOST,
Vice-Chairman.

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[1] See p. 603.

APPENDIX

PROPOSED REVISIONS

IN

TENTATIVE SPECIFICATIONS FOR SEWER PIPE.

Committee C-4 recommends that the following revisions be made in the Tentative Specifications for Clay Sewer Pipe (C 13 - 18 T).[1]

1. *Section 16.*—Change the third and fourth paragraphs to read as follows:

> "Water pressures, as measured by a standardized gage attached to the delivery pipe close to the specimen, shall be internally applied to the specimens as follows:
>
> 5 lb. per sq. in. for 5 minutes.
> 10 " " " 10 "
> 15 " " " 15 "
>
> The specimens shall show no leakage under these pressures. Moisture appearing on the surface of the pipe in the form of patches or beads, adhering to the surface, shall not be considered leakage."

2. *Section 26, Table II.*—(*a*) The maximum allowed absorption for clay sewer pipe shall be 8 per cent. Correct Table II accordingly, placing the figure 8 in the fourth column, opposite each size of pipe.

(*b*) Strike out the third column of Table II (now headed "maximum percolation").

3. *Section 27.*—In the first sentence, strike out the word "minimum" and change "Table III" to read "Tables III and IV."

4. *Section 27, Table III.*—Make the following changes in Table III:

(*a*) Add a seventh column, to be entitled "Thickness of Socket," reading as follows:

> "The thickness of the socket $\frac{1}{4}$ in. from its outer end shall not be less than three-fourths of the thickness of the barrel of the pipe."

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XIX, Part I, p. 543 (1919).

(*b*) Change the heading of the third column to read: "Inside Diameter at Mouth of Socket, in."

(*c*) In the fifth column place the word "minimum" above the words "Taper of Socket."

(*d*) Add the following letters to the seven column headings, beginning with the first column at the left:

$$D, L, D_s, L_s, H, T, T_s,$$

and add a sketch showing the points at which the dimensions apply, lettered so as to correspond with the letters in the column headings of Table III, similar to Fig. 4 of the Tentative Specifications for Cement-Concrete Sewer Pipe.

The following revision is recommended in the Tentative Specifications for Cement-Concrete Sewer Pipe (C 14 - 19 T):[1]

Section 26, Table II.—Strike out the third column of Table II (now headed "maximum percolation").

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XIX, Part I, p. 556 (1919).

ADDENDUM
TO
REPORT OF COMMITTEE C-4.

The committee recommends the following additional revisions in the Tentative Specifications for Clay Sewer Pipe (C 13–18 T)[1], and in the Tentative Specifications for Cement-Concrete Sewer Pipe (C 14–19 T)[2], which were approved at a meeting of the committee held during the annual meeting of the Society. Since there has not been an opportunity to refer these revisions to a letter ballot vote of the committee, it is recommended that they be accepted subject to a favorable vote of the committee by letter ballot subsequent to the annual meeting.

Proposed Revisions in the Tentative Specifications for Clay Sewer Pipe (C 13 – 18 T):

1. *Section 26, Table II.*—Add a new size, 4 in. in internal diameter, with minimum crushing strength, 1430 lb. and maximum absorption, 8 per cent.

2. *Section 27, Table III.*—Insert the following requirements for a new size, 4 in. in internal diameter:

Laying length, ft	2
Inside diameter at mouth of socket, in	6
Depth of socket, in	$1\frac{1}{2}$
Minimum taper of socket, in	1 : 20
Thickness of barrel, in	$\frac{9}{16}$

3. *Section 27, Table IV.*—Insert the following requirements in permissible variations in dimensions for a new size, 4 in. in internal diameter:

Length, in. per ft. (–)	$\frac{1}{4}$
Length of two opposite sides, in	$\frac{1}{8}$
Internal diameter, spigot, in., (±)	$\frac{1}{8}$
Internal diameter, socket, in., (±)	$\frac{3}{16}$
Depth of socket, in (–)	$\frac{1}{8}$
Thickness of barrel, in., (–)	$\frac{1}{16}$

4. *Section 30.*—(*a*) Under the number of scorings insert:

"For pipes 4 to 6 in. in internal diameter, inclusive . . . none."

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XIX, Part I, pp. 543–555 (1919).

[2] *Ibid.*, pp. 556–568.

(*b*) Change the present first line to read:

"For pipes 8 to 10 in. in internal diameter, inclusive . . . 2."

PROPOSED REVISIONS IN THE TENTATIVE SPECIFICATIONS FOR CEMENT-CONCRETE SEWER PIPE (C 14 – 19 T):

1. *Section 26, Table II.*—Add a new size, 4 in. in internal diameter, with minimum crushing strength, 1430 lb. and maximum absorption, 8 per cent.

2. *Section 27, Table III.*—(*a*) Insert the following requirements for a new size, 4 in. in internal diameter:

Laying length, ft	2, 2½
Inside diameter at mouth of socket, in	6
Depth of socket, in	1½
Minimum taper of socket	1 : 20
Thickness of barrel	9/16

(*b*) In the present first line, under "Laying Length, ft." add "2½."

3. *Section 27, Table IV.*—Insert the following requirements in permissible variations in dimensions for a new size, 4 in. in internal diameter:

Length, in. per ft (–)	¼
Internal diameter, spigot, in., (±)	⅛
Internal diameter, socket, in., (±)	⅛
Depth of socket, in. (–)	⅛
Thickness of barrel, in. (–)	1/16

EDITORIAL NOTE.

The proposed revision of the Tentative Specifications for Clay Sewer Pipe and of the Tentative Specifications for Cement-Concrete Sewer Pipe, referred to in this report, and the further revisions in these two tentative specifications given in the addendum to this report, were accepted, and the revisions in the addendum subsequently approved by letter ballot vote of the committee. The specifications, as thus revised, were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1920 and appear in the supplementary pamphlet of A.S.T.M. Standards Adopted in 1920.

REPORT OF COMMITTEE C-6

ON

DRAIN TILE.

Committee C-6 has held three meetings during the year,—one at Atlantic City, at the time of the annual meeting of the Society, and the other two in Chicago, February 18 and April 21, 1920, respectively.

The committee membership was increased from fifteen to seventeen during the year by the addition of Mr. G. M. Williams of the U. S. Bureau of Standards, and the Mason City Brick and Tile Company (Mr. Burr Keeler). Mr. L. G. Blackmer, of St. Louis, was appointed on the committee to fill a vacancy. Dean Edward Orton, Jr., has just resigned, reducing the membership to 16.

The committee has revised the Standard Specifications for Drain Tile (C 4 - 16).[1] The specifications seem to have been accepted without criticism so far, but the committee is bringing them up to date, and presents in an appendix to this report[2] proposed revisions, with the recommendation that they be published as tentative for one year before reference to letter ballot for adoption as standard. The revisions are minor in character except in the instance of the standard freezing and thawing test for drain tile. It is recommended that all boiling of specimens in the freezing and thawing test be eliminated. This important change is the result of active and extensive research work on freezing and thawing tests for surface-clay and for concrete drain tile which have been in progress since 1916 at the Iowa Engineering Experiment Station and elsewhere.

This research seems to have led to an entirely unexpected and very interesting discovery—namely, that the boiling of specimens of concrete already set hard for a considerable time causes a marked decrease in tensile and compressive strength, at least for the time being, and consequently in resistance to the freezing and thawing test specified in the present specifications, at least in the case of many cements which are in satisfactory, extensive use. This discovery came through observation of the fact that the present standard freezing and thawing test of drain tile (which requires repeated boiling of pieces of the tile) destroys in a few repetitions samples from concrete tile which withstand mere freezing and thawing perfectly, both in the field and under laboratory conditions simulating field conditions in exaggerated degree.

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[1] 1918 Book of A.S.T.M. Standards.

[2] See p. 817.—Ed.

A similar effect, but not so severe, was observed from boiling pieces of surface clay tile. Laboratory tests of briquettes and cylinders of concrete gave similar decreases of tensile and compressive strengths. G. M. Williams has run check tests with general confirmation of the above results. D. A. Abrams now has under way at Lewis Institute, Chicago, an extensive series of tests on concrete and mortar cylinders in a study of the effect of boiling water and high pressure steam on the strength of concrete. These tests include a wide range in mixtures, consistencies, etc. Specimens will be subjected to boiling water at different ages, and boiled for different periods. A study of the partial results now available shows a reduction in the strength of the concrete due to boiling during periods of boiling up to at least five hours.

The researches on which the recommendation for elimination of boiling treatment in the freezing and thawing test is based have thus been checked by three well-known laboratories and show conclusively that the boiling has an important weakening effect not connected in any way with resistance to freezing and thawing, and not proportional to such resistance.

Another important subject of research in which Committee C-6 is deeply interested is the effect of alkali and of acid soil conditions on the durability of drain tile. The U. S. Bureau of Standards has been working actively in this line with concrete drain tile since 1913. The investigation is not yet complete, but has already developed many data of great interest, including those of several failures of certain types of concrete tile under known severe alkali conditions and of replacements with different types of concrete drain tile, some of which have proven resistant where some of the first tile failed.

Committee C-6 is enlisting some other laboratories to cooperate with the U. S. Bureau of Standards in the attempt to develop some standard chemical tests and test requirements for drain tile, both for those which must resist normal and those which must resist abnormal alkali and acid soil conditions. It is estimated that at least two years will be required to complete the necessary experiments.

This report has been submited to letter ballot of the committee, which consists of 16 members, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

ANSON MARSTON,
Chairman.

J. T. STEWART,
Secretary.

EDITORIAL NOTE.

Proposed revisions of the Standard Specifications for Drain Tile, referred to in this report, were accepted for publication as tentative and appear on page 817.

REPORT OF COMMITTEE C-7

ON

LIME.

Since the last annual meeting of the Society, Committee C-7 has held one meeting in Philadelphia with 12 members in attendance. At that meeting, many matters of great importance were considered. All the sub-committees held sessions in connection with this meeting and reported progress on various subjects which had been under their consideration for the previous six months. Plans were also laid for actively carrying forward other investigations for the balance of the year. The second meeting will be held in connection with the annual meeting of the Society at Asbury Park, N. J., at which time it is expected that many reports previously incomplete will be brought up to date and completed. The principal activities covered during the past year by Committee C-7 are set forth in more detail below.

The committee recommends that the Tentative Specifications for Masons' Hydrated Lime (C 6 - 19 T)[1] be continued as tentative for another year.

The committee has adopted the standard screen scale as promulgated by the U. S. Bureau of Standards.

The committee also recommends that the Executive Committee of the Society be asked to cooperate in the creation of a joint committee of this Society and the American Chemical Society for the development of specifications relating to chemical uses of lime.

Sub-Committees.—While nearly every one connected with commercial life has been working under severely strained conditions during the past year or so, nevertheless many of the subcommittees of Committee C-7 have found time to hold various meetings and otherwise to carry forward the work of the committee.

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[1] See p. 605.

Structural Lime.—Sub-Committee II on Structural Lime regrets to report that it has been unable to obtain a satisfactory standard sand for use in laboratory tests of lime. It also regrets that the desired cooperation with Committees C-1, C-9 and C-11 has not yet been perfected in detail.

After a general review of its previous work the sub-committee finds that there are some fifteen properties which should be included in specifications for different kinds of structural lime. It is now prepared to write the requirements for most of these properties. Information is required concerning a few properties, and the year has been spent in the development of the necessary test data. The items of particular interest are plasticity and soundness.

In view of the fact that the Executive Committee of the Society has ruled that this Society has no jurisdiction over the application of wall plasters, our secondary committee on this subject, which has been actively endeavoring for two years to write plastering specifications, has been disbanded.

Committee C-7 will endeavor to write specifications for sand to be used with lime as a structural material.

Lime for the Chemical Industries.—Some changes have been made in the personnel of Sub-Committee III on Lime for the Chemical Industries, which, it is believed, will enable it to carry forward its work more effectively.

The former designation of "Sub-Committee on Chemical Lime" has been changed to the present designation as it is believed this name is more truly indicative of the scope of the activities of the sub-committee.

The cooperation of committees from various other organizations has been secured, and, while no specifications are now being presented to the Society, several tentative specifications have been prepared by this sub-committee and are now being considered by Committee C-7. These specifications cover the use of lime in water purification, certain paper-making processes, and a number of other industries.

Agricultural Lime.—In addition to being sponsor for the adoption of the standard screen scale, Sub-Committee IV on Agricultural Lime has given serious consideration to several other problems of great importance. An investigation has been undertaken to determine the factors affecting the solubility of lime carbonates. An attempt has been made to determine the essential provisions which should be included in an agricultural lime inspection law and to formulate a model law, the provisions of which can be embodied in regulatory measures of all states.

Other subjects of equal importance are receiving the attention of the sub-committee.

Chemical Analysis.—Sub-Committee V on Chemical Analysis is considering criticisms of the Tentative Methods for Chemical Analysis of Limestone, Lime and Hydrated Lime (C 25 – 19 T)[1] with a view to recommending certain changes. It is continuing its efforts to develop methods of analysis for the determination of some of the rarer constituents sometimes encountered in lime and limestone. A recent paper by Mr. G. F. Loughlin of the United States Geological Survey calls attention to the great industrial importance as well as the scientific value of determining such constituents as ferrous iron, fluorine, strontium, and other elements occurring in limestone. In view of the apparent importance of this matter, the personnel of this sub-committee has been increased in order to enable it more efficiently to perform its functions in this expanded field of effort.

Plasticity.—Sub-Committee VI on Plasticity has made extensive use of a plasticimeter, developed by the U. S. Bureau of Standards. This has been done with three main objects in view:

1. To ascertain how results obtained by use of the machine compare with practical field observations;
2. To compare the plasticities of different kinds of lime;
3. To develop some preliminary data bearing on plasticity.

Highway Lime.—Sub-Committee VII on Highway Lime has been cooperating with the State Highway Department of Delaware in conducting extensive field experiments to determine the value of lime in concrete road construction. The results of these tests have very recently become available to the members of the sub-committee and have shed considerable light upon problems which are under consideration.

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[1] See p. 626.

A point of contact has been made with the U. S. Bureau of Public Roads and Rural Engineering for the purpose of conducting similar tests.

In view of the notice received from the Executive Committee that a Standing Committee on Nomenclature will be created by the Society, Committee C-7 has appointed Mr. H. C. Berry to be its representative on this new committee. It also respectfully refers to this new committee the definition of "plasticity" as proposed by Committee C-7 in its 1919 report.[1]

This report has been submitted to letter ballot of the committee, which consists of 28 members, of whom 18 have voted affirmatively, none negatively, and 10 have refrained from voting.

Respectfully submitted on behalf of the committee,

D. KNICKERBACKER BOYD,
Chairman.

SIDNEY P. ARMSBY,
Acting Secretary.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XIX, Part I, p. 310 (1919).

REPORT OF COMMITTEE C-8

ON

REFRACTORIES.

Committee C-8 has held three general meetings during the year.

The following recommendations submitted by the respective sub-committees have all been approved by the main committee and submitted to letter ballot vote. The results of this letter ballot in connection with each recommendation involving revision or the submission of tentative tests or methods as standard are given in tabular form at the end of the report.

Sub-Committee I on Fusion Test.—In pursuance of the report of Sub-Committee I, the committee recommends that the present Tentative Test for Determination of Softening Point of Fire Clay Brick (C 24 – 19 T),[1] be submitted to letter ballot of the Society for adoption as standard.

Sub-Committee II on Analysis.—In pursuance of the report of Sub-Committee II the committee has presented methods for the complete and rapid analysis of chrome materials, appended hereto, and recommends that these methods be published by the Society as tentative standards.

The committee also recommends that the present Tentative Methods for the Ultimate Chemical Analysis of Refractory Materials (C 18 – 18 T)[2] be submitted to letter ballot of the Society for adoption as standard.

Sub-Committee III on Industrial Survey—The sub-committee has no report to offer at this time.

Sub-Committee IV on Thermal Conductivity and Expansion.—The sub-committee has no report to offer at this time.

Sub-Committee V on Porosity and Permanent Volume Change.—In pursuance of the report of Sub-Committee V, the committee recommends that the present Tentative Test for the Determination of Porosity and Permanent Volume Changes in Refractory Materials (C 20 - 18 T)[1] be submitted to letter ballot of the Society for adoption as standard.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XIX, Part I, p. 594 (1919).

[2] *Ibid.*, p. 605.

Sub-Committee VI on Load Test.—Sub-Committee VI reports that they desire to add as footnotes the following explanatory sentences to the present Tentative Test for Refractory Materials under Load at High Temperatures (C 16 - 18 T):[2]

> "Gross errors which may more than double the contraction will result if the specimen is not set perpendicular to the base of the support or if the load is eccentrically applied."
>
> "The specimen shall be examined immediately after the heating is stopped for evidences of cracking and spalling as such defects may develop later due to the rapid cooling of the furnace."

In pursuance of the report of Sub-Committee VI, the committee recommends that the present Tentative Test for Refractory Materials Under Load at High Temperatures (C 16 - 18 T),[2] be submitted to letter ballot of the Society for adoption as standard.

Sub-Committee VII on Spalling Action.—This sub-committee has no report to offer at this time.

Sub-Committee VIII on Slagging Action.—As the result of the letter ballot, the committee recommends that the present Tentative Test for Slagging Action of Refractory Materials (C 17 - 19 T)[3] be continued as tentative.

Sub-Committee IX on Nomenclature.—This sub-committee has no report to offer at this time.

Sub-Committee X on Micro-Structure.—This sub-committee has no report to offer at this time.

Special Sub-Committee on Definitions.—The committee recommends in pursuance of the report of this special sub-committee that the Tentative Definitions for Clay Refractories (C 27 - 19 T),[4] be submitted to letter ballot of the Society for adoption as Standard.

The result of the letter ballot of the committee on the various recommendations is as follows:

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XIX, Part I, p. 590 (1919).

[2] *Ibid.*, p. 581.

[3] *Ibid.*, p. 586.

[4] *Ibid.*, p. 625.

Items.	Affirmative.	Negative.	Not Voting.
I. RECOMMENDED FOR ADOPTION AS STANDARD.			
Tentative Test for Softening Point of Fire-Clay Brick (C 24 – 19 T)	32	1	9
Tentative Methods for the Ultimate Chemical Analysis of Refractory Materials (C 18 – 18 T)	34	0	8
Tentative Test for Porosity and Permanent Volume Changes in Refractory Materials (C 20 – 18 T)	32	0	10
Tentative Test for Refractory Materials Under Load at High Temperatures (C 16 – 18 T)	31	1	10
Tentative Definitions for Clay Refractories (C 27 – 19 T)	30	2	10
II. RECOMMENDED FOR PUBLICATION AS TENTATIVE.			
Proposed Method for Ultimate Chemical Analysis of Chrome Ores and Chrome Brick	30	0	12

This report has been submitted to letter ballot of the committee, which consists of 42 members, of whom 32 have voted affirmatively, none negatively, and 10 have refrained from voting.

Respectfully submitted on behalf of the committee,

A. V. BLEININGER,
Chairman.

W. H. FULWEILER,
Secretary.

EDITORIAL NOTE.

The Tentative Test for Softening Point of Fire-Clay Brick, the Tentative Methods for the Ultimate Chemical Analysis of Refractory Materials, the Tentative Test for Porosity and Permanent Volume Changes in Refractory Materials, the Tentative Test for Refractory Materials under Load at High Temperatures, and the Tentative Definitions for Clay Refractories, referred to in this report, were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1920 and appear in the supplementary pamphlet of A.S.T.M. Standards Adopted in 1920.

The proposed Tentative Method for Ultimate Chemical Analysis of Chrome Ores and Chrome Brick was accepted for publication as tentative and appears on pages 647–651.

A paper by Raymond M. Howe entitled "Vital Factors in the Testing of Fire-Clay Refractories and in the Interpretation of Results" was accepted at the annual meeting as an appendix to the report of Committee C-8 (see Summary of Proceedings, page 23) and appears on pages 278–290.

APPENDIX.

VITAL FACTORS IN THE TESTING OF FIRE-CLAY REFRACTORIES AND IN THE INTERPRETATION OF RESULTS.

By Raymond M. Howe.

It is a fact well known to those who are in a position to compare the results of laboratory tests and plant service, that the results obtained by these two do not always agree. This condition is serious and it is hoped that more reliable tests may be developed in certain cases, or that the present ones may be modified so that their weaknesses may be overcome and the interpretation of results simplified.

Data relative to this phase of testing have been accumulated over a period of several years; hence they do not represent a specific investigation but are taken from the results of several. A preliminary statement is given regarding the types of first-quality fire clay used and the processes of manufacture which are applied. It is believed that the influence of these factors upon the physical structure of the brick is most vital in controlling the results of tests, and when disregarded often leads to the formation of erroneous conclusions.

Raw Materials.

There are at least five distinct types of first-quality fire clay and there are undoubtedly as many of second quality, although the latter will be disregarded at the present time.

A. Flint clays.[1]

1. Highly refractory, open-burning, constant in volume over a wide range of temperature, and practically non-plastic.
2. Highly refractory, dense burning, contracts upon exposure to high temperatures, and becomes plastic when ground with water.

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[1] A. V. Bleininger, "The Testing of Fire-Clay Refractories," *Technologic Paper No. 7*, U. S. Bureau of Standards, p. 41. (See volume change curves.)

B. Plastic clays.[1]

3. Highly refractory, open-burning, relatively constant in volume over a wide temperature range, and of various degrees of plasticity. With the exception of certain kaolins, the clays of this type are not very plastic.

4. Highly refractory, dense-burning, and usually of high plasticity. Clays of this type become dense at relatively low temperatures and remain so over a wide temperature range.

C. "Hardsoft" or semi-flint clays.

5. These clays are usually highly refractory, of low plasticity, dense burning, and of fairly constant volume. They possess properties of both the plastic and flint clays and are therefore difficult to classify as either.

MANUFACTURE.

There are at least six distinct steps in the process of manufacture which control the final characteristics of the finished brick, and there are many other details of minor importance. The more important influences are as follows:

1. Raw material
    - (*a*) Plasticity
    - (*b*) Burning and drying behavior
    - (*c*) Proportions of different ingredients in the mix;
2. Grind;
3. Water content of mixture;
4. Time of tempering;
5. Method of shaping;
6. Degree of burning.

In many cases a single clay, of type 2, 4 or 5, is used in the manufacture of fire brick. When this is done the resulting product is usually more dense than that made from a mixture of different materials, part of which have low plasticity. It is a simple matter to temper and shape a "one-clay" batch, yet the drying and burning problems are often more serious. These latter factors of course depend upon the texture of the ware.

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[1] A. V. Bleininger, "The Testing of Fire-Clay Refractories," *Technologic Paper No. 7*, U. S. Bureau of Standards, p. 41. (See volume change curves.)

Theoretically, there are certain combinations of sizes which will produce the densest mass, and all other proportions will give a larger percentage of pore space. This rule applies to fire-clay mixes in a general way, but little or no application of the principle is made in practice. The raw materials are usually ground to a certain maximum size but the other sizes are disregarded. A suitable variation is secured by following this practice and a dense product results from fine grinding, while the coarser grinds are associated with a more open structure.

When the maximum or minimum amounts of water are used in tempering the clay, the resulting products, generally speaking, are not so dense as those made from "stiff" mud.[1] There are other factors, however, such as the burning behaviors of the clays, that modify this statement.

The plasticity of a clay increases gradually as it is tempered. Consequently clays which are tempered for a long time have a greater bonding power and produce a stronger product than those only superficially tempered. In one instance the strength of the burned product was increased 28 per cent by longer pugging, while in a more unusual case the increase was practically 100 per cent. These figures offset the erroneous impression that most of the strength of a brick is developed during the shaping or burning periods. The condition of the clay at the time of shaping exerts fully as great an influence as either of the other two factors.

When the brick is being shaped by hand or with a soft-mud machine, the clay mixture is usually rather plastic and contains a relatively large amount of water. Since very little pressure is exerted in these processes, and since the excess of water is incompressible, the resulting product is usually open and porous.

When an auger machine or sewer pipe press is being used, the mud is stiff and there is no excess of water. As a result, when clay of this nature is subjected to the relatively high pressure of those machines, a very dense product is formed.

The dry-pressed product is made under high pressure but only a small amount of water is added to the clay. As a result, the clay is not plastic and does not flow readily in the die. The product is not as dense as that made on a stiff-mud machine. It resembles the hand-made product in some respects and the stiff-mud in others, varying to some extent with the water content.

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[1] For experimental data see C. E. Nesbitt and M. L. Bell, "Practical Methods for Testing Refractory Fire Brick," *Proceedings*, Am. Soc. Test. Mats., Vol. XVI, Part II, p. 364 (1916).

R. M. Howe, "The Work of the Technical Division of the Refractories Manufacturing Association," *Journal, Ind. Eng. Chem.*, Vol. II, p. 1145 (1919).

After the ware has been shaped, its behavior in drying and burning will depend upon the nature of the raw clays involved. Often the product must be burned to a very high temperature in order to remove further shrinkage and secure the necessary strength; at other times this strength is obtained at lower temperatures because of the natural dense-burning nature of the clays, although the shrinkage is not always completely removed. In other cases, the shrinkage is removed at low temperatures but the mechanical strength is not fully developed.

LOAD TEST.

The load test has been applied for a very short time, relatively speaking, but nevertheless has become accepted as one of the more important tests. The method of procedure has been given elsewhere[1] and hence will not be repeated. Suggestions have been made as to how much a good brick should compress, and the limits given are placed at from 3 to 10 per cent. There is another phase, however, which has not been discussed, and concerning which there are sufficient data available at present to offer for consideration.

There are evidently several factors, other than the raw materials, which influence the compression obtained in this test. They are:

1. Tempering of raw clay;
2. Process of manufacture;
3. Degree of firing.

The influence of the time of tempering is shown by the fact that two bricks of the same mixture compressed 7.85 and 4.45 per cent, respectively. They were molded in the same machine and were burned in the same kiln. Those showing the lower compression were pugged for a longer period of time but otherwise there was no difference.

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[1] Tentative Test for Refractory Materials Under Load at High Temperatures, *Proceedings*, Am. Soc. Test. Mats., Vol. XVII, Part I, p. 665 (1917).

In another case it was found that hand-made brick compressed 17.0 per cent while steam-pressed brick made from the same mix compressed only 5.7 per cent.

Hard burned brick were found to compress 5.55 per cent while light burned brick from the same kiln compressed 7.53 per cent. As in the other cases, there was only one known difference in the specimens tested.

When these results are summarized it is obvious that the factors which favor the production of a dense brick also favor its behavior in the load test. Consequently, when similar clays are used the more open product will be tested at a disadvantage.

The problem then arises as to how the results should be interpreted, and the following questions indicate the difficulty of this task:

1. Where are the test conditions found in service? Where do they occur to an approximate degree? When is one end of the brick cooler and hence able to carry the load?

2. Where will a light-burned brick of open structure give better service than a dense hard-burned brick, although the latter gives the better results in the test?

3. What allowance should be made for the influence of burn, structure and process of manufacture?

4. Where so many factors enter, should the allowable compression be low (3 per cent) and thus eliminate the majority of first-quality fire brick, or should it be higher (10 per cent) so that the more open bricks of suitable quality can pass the test?

FUSION TEST.

This particular fusion test is one of the oldest of the more scientific tests and is used far more extensively than any other. Furthermore, when bricks of approximately the same type (with respect to the clays used and process of manufacture) are being compared, results are obtained which agree very closely with those observed in service. This holds true with this exception: There are five districts in the United States where very siliceous clays are found which fuse at Cone No. 28. This is due to the fact that pure alumina and silica, when mixed in the ratio of

1 to 4, fuse at about that temperature. Consequently, bricks made from such clays do not have a particularly high fusion point. They do, however, give very good service in many positions, because of their open structure and constant volume at temperatures close to their fusion point. The more desirable of this type may be easily distinguished by the fact that they show little or no compression in the 1350° C. load test.

SPALLING TEST.

The spalling test has been studied very carefully and as the results have been published[1] the experimental data and methods of testing will not be repeated. The conclusions which were drawn are as follows:

1. When a given source of clay is available and brick are made therefrom, the test will give accurate information regarding the influence of the following factors upon the resistance of the brick to spalling:

   (*a*) Grind;
   (*b*) Process of manufacture;
   (*c*) Firing.

2. When *different* kinds of clay are used in the manufacture of fire brick, and these brick are tested, the results of the spalling test do not necessarily agree with practical experience. This condition is due to the fact that the spalling test disregards the natural characteristics of the raw clays from different districts and over-emphasizes the influence of the other three factors mentioned (*a*, *b*, and *c*).

3. When brick of the most refractory type are heated for five hours at 1400° C. before being subjected to the spalling test, those which spall in service will vitrify during heating and will therefore fail more quickly when subsequently subjected to the spalling test.[2]

Since the appearance of the original article,[1] four brands of brick, made by one manufacturer, have been tested for resistance to spalling. The characteristics of the different brick, which were all hand made, are as follows:

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[1] R. M. Howe and R. F. Ferguson, "A Study of Spalling," *Journal*, Am. Ceram. Soc., 3 (1920).

[2] It has since been found that the time of pugging exerts a controlling influence upon the resistance to spalling.

1. A coarse grained brick made from 85 per cent of open-burning flint clay and 15 per cent of unusually refractory plastic clay.

2. A fine grained brick made from 100 per cent of the plastic clay used in Brand No. 1.

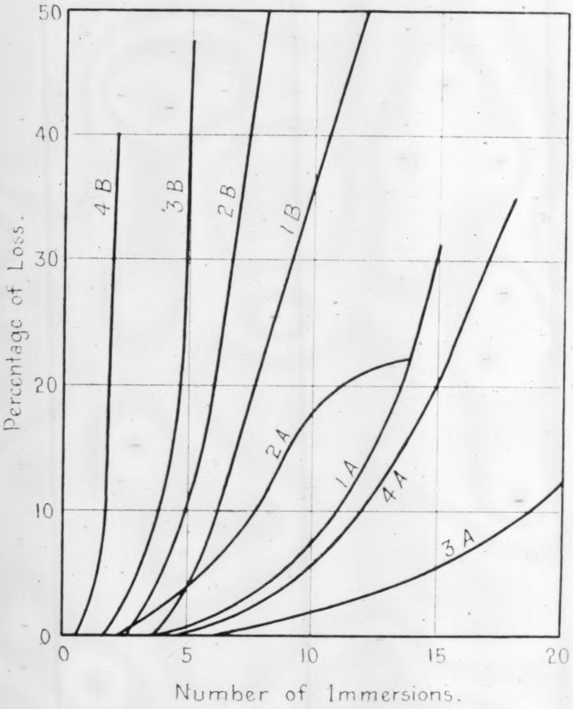

FIG. 1.—Resistance to Spalling of Fire-Clay Bricks.

3. A coarse grained brick made from 85 per cent of flint clay of medium refractoriness and 15 per cent of medium quality clay of high plasticity.

4. A fine grained brick made from 100 per cent of the plastic clay used in Brand No. 3.

In actual service, No. 1 brick offers the greatest resistance to spalling, No. 2 brick is the next best and No. 4 brick spalls the most. The results obtained by subjecting these various brands to the spalling test are shown by the curves 1*A*, 2*A*, 3*A* and 4*A*, Fig. 1. In other words, the two brands which give the best results in service (1 and 2) failed most rapidly in the test.

When the test specimens were first heated for five hours at 1400° C., and were then subjected to the spalling test, the results shown in curves 1*B*, 2*B*, 3*B* and 4*B* of Fig. 1 were obtained. These latter results are in strict accordance with the conclusions formed from years of experience.

The difference in the relative positions of curves 1, 2, 3 and 4 when taken from run-of-kiln brick and when taken from brick which were previously heated at 1400° C. is easily explained. Bricks 1 and 2 were bonded with a very refractory plastic clay which was relatively short and they were therefore not so thoroughly bonded as bricks Nos. 3 and 4, in which a very plastic clay was used. Since the usual spalling test emphasizes brick structure, it is not surprising that the best bonded bricks gave the best results in a test of this nature.

When the bricks were heated for five hours at 1400° C. the high grade bonding clay in 1 and 2 was scarcely affected, while the less refractory bond clay in 3 and 4 showed the harmful effects of excessive heat treatment. Consequently the heated brick withstood the conditions of the spalling test in the order of their resistance to high temperatures, but the influence of the mix and grind was also apparent.

Although there are objections to heating a brick before subjecting it to the spalling test, it is believed to be good practice, in general, where different types of fire clay are involved. By combining the two tests the characteristics of the raw clays, as well as the physical properties of the brick, are taken into consideration. The spalling test, when used alone, over-emphasizes the influence of brick structure and disregards the marked influence of the raw materials used. The chief objection to reheating before spalling lies in the fact that in many cases resistance to spalling is increased by light burning—a preliminary heat treatment might not take this fact into consideration.

SLAG TEST.

The slag test, being of later origin, was studied from several angles in order to develop any possible factors which might influence the results. The factors studied were as follows:

1. Influence of time;
2. Influence of quantity;
3. Influence of temperature;
4. Influence of furnace atmosphere;
5. Method of reporting results:
6. Relation between the results of laboratory and plant tests.

Hard-burned, hand-made, finely ground metallurgical brick from the Pennsylvania district were used in studying the first five influences. Each brick contained 2 pockets 2½ in. in diameter and ½ in. deep. Unless otherwise specified, the samples were heated to 1350° C., at which temperature the slag was added and allowed to react for two hours, in an oxidizing furnace atmosphere. They were then allowed to cool, and the area of penetration across the center of the cavity was measured by means of a planimeter. Since the length of the line of contact between the slag and the cross-section of the original cavity varied, the total penetration was divided by this line and the results were therefore expressed in terms of average penetration.

Preliminary tests showed that the samples were sufficiently uniform to give results which checked within 12 per cent. Subsequent tests given below show the effect of varying the quantity of slag used and the time of testing on the average penetration of copper slag (M. P. = 1020° C.):

QUANTITY.	TIME.	PENETRATION.
35 g	2 hr.	0.64 in.
35 g	4 hr.	0.68 in.
35 g	6 hr.	0.64 in.
105 g	2 hr.	0.76 in.
105 g	4 hr.	0.72 in.

These results show that, although the severity of the test was apparently varied over a range of 600 per cent, the penetrations varied only to the extent of 19 per cent; the effect of either time or quantity is, therefore, practically negligible, within the given limits. Later, the temperature of testing and the furnace atmosphere were varied with the following results upon the penetration of copper slag:

Temperature	1150° C.	1250° C.	1350° C.	1450° C.
Average penetration in oxidizing atmosphere, in.	0.52	0.62	0.83	0.46
Average penetration in reducing atmosphere, in.	....	0.45	0.45	0.30

This shows very clearly that the penetration depends to a large extent upon the furnace atmosphere, when the slag contains considerable quantities of an easily reducible metallic oxide. In order to insure uniform conditions the atmosphere should be kept oxidizing, thus avoiding various degrees of partial reduction.

The results also show a greater penetration at 1150° C. than at 1450° C., although the recorded results do not give a correct impression as to the actual results of these two tests. At 1150° C. the slag simply melted and ran into the pores; it did not attack the flint clay particles or destroy the structure to any noticeable degree. At 1450° C., the slag took the brick completely into solution as it penetrated. Consequently the action at 1450° C., although recorded by a lower figure, was far more severe than that at 1150° C.

This same condition has been noted from time to time and it is difficult to express the results clearly. It would certainly be unfair, however, to give the same rating to a brick taken completely into solution as to one which was simply penetrated mechanically. It is also a very difficult matter to express just how much of the action is chemical and how much is physical, where different materials are being compared.

In another investigation, three kinds of brick were compared which had been used in checkers where the slagging action was particularly severe. No. 1 bricks were of first quality, yet did not give the service secured from bricks Nos. 2 and 3 (those numbered 2 and 3 were made from another mix by two different processes). The various data available regarding these comparisons are as follows:

TYPE.	GRIND.	PROCESS OF MANUFACTURE.	FUSION POINT.	SLAG PENETRATION USING 35 G. OF BASIC SLAG FOR 2 HOURS AT 1350° C.	SERVICE.
1	Fine	Steam Press	Cone 31½	0.29 in.	Fair
2	Medium	Hand	Cone 32½	0.52 in.	Good
3	Medium	Steam Press	Cone 32½	Practically zero	Good

Thus it can be seen that bricks of type No. 2, which replaced those of No. 1 permanently, did not give as good a slag test, although they were all destroyed in service by the action of slag. Brick No. 3, made from the same clays and mix as No. 2, gave a far superior slag test but did not give any longer service. In other words, the test results were not consistent with the service obtained.

Later it was found that chrome brick were penetrated 0.46 in. by the same slag under the same conditions; magnesite brick were penetrated 0.20; three other types of fire-clay brick were penetrated 0.44 in., 0.58 in., and 0.29 in., respectively.

These results agree roughly with those secured by G. H. Brown[1] of the United States Bureau of Standards, who found that a basic slag completely penetrated silica, magnesite, and bauxite brick while it penetrated fire-clay brick according to their texture. He was very much surprised at these results because of the fact that the acid, basic, and neutral refractories offered similar resistance to the penetration of such a basic slag.

In view of the results secured at different times, it is evident that the slag test leads to erroneous results, and the following facts are offered as the basis for this conclusion:

1. The measured penetration is the same for 6 hours as it is for 2 hours, although in service the amount of action is a function of time.

2. When the amount of slag is increased fourfold, the penetration per inch of contact remains practically the same.

3. There are two kinds of action, chemical and physical, and no method of measuring penetration will tell which predominates.

4. When the test is applied to fire brick, the penetration does not give definite information regarding the ability of different brick to resist the action of slag. Chrome brick show greater penetration by basic slag than is noted with fire-clay brick and it is therefore doubtful whether chrome brick would ever be used to resist slag action on the basis of the test.

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[1] G. H. Brown, "A Method of Testing the Corrosive Action of Slags on Fire Brick," *Transactions*, Am. Ceram. Soc., Vol. 18, p. 279 (1916).

REHEATING TEST.

The reheating test is sometimes used either to check the results of the load test or to replace it entirely. As a rule the results secured need no amplification but may be compared directly. There are times, however, where it is possible that erroneous conclusions may be drawn, for when a given mixture of clays was molded by hand in one instance and by steam press in another, the resulting products gave far different results in the test.

It is sometimes a fact that the dense machine-made product will expand excessively during the test while the more open hand-made product will not. This latter fact, verified by a fusion test of Cone No. 32½, indicates that the raw material is very refractory but that the excessive expansion noted with the steam pressed product is a function of density. In this particular case, the expansion is therefore not a true measure of refractoriness, or an indication of unsuitable raw material, but is the result of the action of other factors which should be taken into consideration.

SUMMARY.

The data given have shown that the results obtained depend upon the nature of the raw material as well as upon the structure of the product. As a result, a very dense brick will give better results in a load test than one which is more open, although the raw material and open structure of the latter may make it particularly suited for many kinds of service. Likewise, a highly siliceous brick may have a relatively low fusion point yet give superior service in roofs because of its constancy in volume and open structure. In other cases a brick may expand excessively in the reheating test because of the fact that it is extremely dense, yet it may give very good service in certain positions for this reason. Some very refractory clays are rather short and hence the product made therefrom is not particularly well bonded. As a result, brick of this type may fail quickly in the spalling test yet may be very resistant to spalling because of their high refractoriness.

These peculiarities are revealed if the nature of the raw material, as well as the structure of the brick, is taken into consideration.

In the case of the spalling test, both factors are involved if the specimens are given a preliminary heat treatment. This practice might also be applied to the load test. In other cases, the use of a combination of tests is probably the best remedy, for there are too many factors involved in service to justify the formulation of conclusive results from a limited amount of data.

Since there are five types of clay and as many processes of manufacture, the number of combinations is rather large. For this reason, a consumer, who is not restricted as to raw material, must take all of these possibilities into consideration. This same statement applies to the larger manufacturers who have plants in several districts.

The smaller manufacturer is generally limited as to raw material and hence he is confronted by a less serious problem. He must simply make use of tests which indicate the relative characteristics of brick made by different processes.

REPORT OF COMMITTEE C-9

ON

CONCRETE AND CONCRETE AGGREGATES.

Three meetings of Committee C-9 were held during the past year, including that held during the annual meeting of the Society. The work of the committee has proceeded vigorously in the absence of some of the disturbing influences of last year, notwithstanding active construction conditions which have produced an abnormal demand on the attention of the members of the committee.

A great many test results have been obtained in the past several years, and some of these results have been analyzed and worked up in the form of reports or tentative standards.

Some of the aims of the committee are to determine how to specify concrete aggregates and their combinations to obtain amply strong and economical concrete, determine the best methods for testing concrete and its constituent materials, and decide on definitions which are now ambiguous for terms used in connection with concrete and concrete materials. A general idea of the separate problems on which the committee is working may be gained by reviewing briefly the work of the various sub-committees.

Sub-Committee II on Laboratory Tests for Concrete and Laws of Mechanical Mixtures is attempting to determine the effect of size and grading and other characteristics of aggregates on their concrete-making properties, with the idea of showing the practical application of these laws. A large amount of information on this subject has been collected by a number of investigators. The most important work of this sub-committee during the year was done jointly with Sub-Committee VI. These two sub-committees spent several days at the Lewis Institute, Chicago, in a study and discussion of the tests made there and elsewhere. As a result of this joint session a cooperative series of tests have been outlined for the purpose of checking the validity of certain laws already proposed for proportioning concrete. It is hoped that the results of these tests will aid in clearing up certain mooted points which have been much discussed during the past several years. The methods of laboratory manipulation outlined in this series and the schedule of cooperative tests are included in Appendix I of this report.

Sub-Committee III on Sampling and Testing Field Concrete has outlined Methods for Making and Storing Specimens of Concrete in the Field which are appended hereto[1] with the recommendation that they be accepted by the Society for publication as tentative. These methods are based upon and are substantially the same as methods suggested in the report of the committee for 1917.[2]

Sub-Committee IV on Relative Values of Various Strength Tests presented a report to the main committee last year and the results of its work are recorded in the minutes of Committee C-9. The above-mentioned series of tests outlined by Sub-Committees II and VI will serve to check the conclusions reached by Sub-Committee IV.

Sub-Committee V on Impurities Affecting Fine Aggregates has been conducting investigations through the work at Lewis Institute on the effect of organic impurities on the strength of concrete. Part of this work is included in Appendix II and it is shown that a very small percentage of tannic acid has a deleterious effect on the strength of concrete. A Tentative Standard Color Test for Organic Impurities in Fine Aggregates will probably be formulated during the coming year. The Method pursued in making this test was first suggested in the report of the committee for 1917[3] and was described in the last annual report of the committee under the caption "Abrams-Harder Field Test for Organic Purities in Sands."[4]

Sub-Committee VI on Methods of Tests for Voids, Weights, Density, Specific Gravity and Consistency has analyzed tests made under its direction during the past several years, using a number of different methods for determining the weight per cubic foot of aggregates, and as a result has recommended a Tentative Test for Unit Weight of Aggregate for Cement Concrete, using the so-called rod method. Concordance of results, and the fact that the weight thus obtained represented the degree of compactness of the aggregate when in concrete were the main considerations affecting the selection of this test as a tentative standard. A description of the methods of tests employed in these investigations appears in Appendix III. The committee recommends that this method be accepted by the Society for publication as tentative.

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[1] See p. 653.—Ed.

[2] *Proceedings*, Am. Soc. Test. Mats., Vol. XVII, Part I, p. 322 (1917).

[3] *Ibid.*, p. 327.

[4] *Proceedings*, Am. Soc. Test. Mats., Vol. XIX, Part I, p. 321 (1919).

Sub-Committee VI has also formulated a Method for the Determination of Voids in Fine Aggregate for Cement Concrete, which the committee recommends to be accepted by the Society for publication as tentative.

As a result of the investigations completed or being made by the committee, it should be possible to formulate satisfactory specifications for fine aggregate for concrete during the coming year.

The result of a letter ballot of the committee on the tentative standards and appendices was as follows:

Items.	Affirmative.	Negative.	Not Voting.
Appendix I, Outline of Compression Tests of Concrete for Investigation of Properties of Concrete Mixtures	- - - - -	- - - - -	- - - - -
Appendix II, Effect of Tannic Acid on the Strength of Concrete	- - - - -	- - - - -	- - - - -
Appendix III, Report of Sub-Committee VI on Weight, Voids, Density, Specific Gravity, and Consistency	- - - - -	- - - - -	- - - - -
Proposed Tentative Methods for Making and Storing Specimens of Concrete in the Field	22	1	7
Proposed Tentative Test for Unit Weight of Aggregate for Cement Concrete	22	0	8
Proposed Tentative Method for Determination of Voids in Fine Aggregate for Cement Concrete	20	2	8

This report has been submitted to letter ballot of the committee, which consists of 30 members, of whom 22 have voted affirmatively, none negatively, and 8 have refrained from voting.

Respectfully submitted on behalf of the committee,

SANFORD E. THOMPSON,
Chairman.

A. T. GOLDBECK,
Secretary.

EDITORIAL NOTE.

The proposed Tentative Methods for Making and Storing Specimens of Concrete in the Field, the proposed Tentative Test for Unit Weight of Aggregate for Cement Concrete and the proposed Tentative Method for Determination of Voids in Fine Aggregate for Cement Concrete, referred to in this report, were accepted for publication as tentative and appear on pages 653, 624 and 652 respectively.

APPENDIX I.

OUTLINE OF COMPRESSION TESTS OF CONCRETE FOR INVESTIGATION OF PROPERTIES OF CONCRETE MIXTURES.

INTRODUCTION.

The following notes refer primarily to methods to be followed in carrying out compression tests of concrete in Series 201 outlined by Committee C-9 on Concrete and Concrete Aggregates. Series 201 constitutes a study of the effect of size and grading of aggregates, and of variations in the quantities of cement and water on the strength and other properties of concrete. Compression tests of concrete will be made on 6 by 12-in. cylinders at the age of 28 days, using aggregates of different types. A skeleton outline of the tests in Series 201 is attached.

The following methods are in general applicable to the making of specimens in many lines of experimental studies of concrete.

MATERIALS.

The cement and aggregates to be used should be prepared in advance and put aside in order to minimize variations during the period of making the specimens.

Cement.—The cement should conform to all of the requirements of the Standard Specifications and Tests for Portland Cement (C 9–17) of the American Society for Testing Materials.[1] It is recommended that a composite cement made up by thoroughly mixing equal parts of three or more local brands of Portland cement be used. Store cement in a dry place.

Fine Aggregate.—Series 201 includes tests with two types of fine aggregate:

1. Commercial concrete sands.
2. Stone screenings.

It is not essential that the fine aggregate conform to any strict requirements for size or grading. Sand or screenings for

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[1] 1918 Book of A.S.T.M. Standards.

Groups 1, 2, 3 and 4 should all pass a No. 4 square mesh sieve and be free from organic impurities. Local materials of commercial grade are desired.

In Group A, fine aggregate from the same shipment finer and coarser than those in the major group should be used. If the fine aggregate used in the major group is graded 0 to No. 4, those in Group A may be graded 0 to No. 8 or 0 to No. 14 for the fine sand and 0 to $\frac{3}{8}$-in. for the coarse size.

Coarse Aggregate.—Three types of coarse aggregate will be used in Series 201:

1. Pebbles.
2. Crushed stone.
3. Crushed slag.

In general, the material should be graded from No. 4 sieve to about $1\frac{1}{2}$ in. It is not necessary that the grading should conform to any strict requirements. Any crushed stone of commercial quality may be used in Groups 2 and 4.

Water.—Any potable water is satisfactory.

TESTS OF CONCRETE MATERIALS AND CONCRETE.

Before beginning the concrete tests make triplicate tests on aggregate samples. Accurate data on sieve analysis and unit weight of aggregate are necessary before the concrete can be proportioned for the purpose of these tests. Special care should be used to secure representative test samples.

Cement.—During the season of making the concrete specimens, make triplicate standard tests of cement on independent samples as follows:

1. Soundness.
2. Time of setting.
3. Mortar strengths at ages of 7 and 28 days.
    (*a*) Briquettes.
    (*b*) 2 by 4-in. cylinders.
4. Fineness.

All cement tests should be made in accordance with the Standard Specifications and Tests for Portland Cement (C 9–17) of the American Society for Testing Materials.[1] Make standard sand mortar tests at same time as mortar strength tests of fine aggregate described below.

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[1] *Loc. cit.*

The following tests should be made on aggregate and concrete:

Fine Aggregate.—

1. Sieve analysis.
2. Colorimetric test for organic impurities. (Sands only.)
3. Unit weight.
4. Mortar strength 1:3 mixtures *by weight* and *by volume*, at ages of 7 and 28 days.
    - (*a*) Tension tests of briquettes.
    - (*b*) Compression tests of 2 by 4-in. cylinders.

    (In all of the mortar strength tests the values reported should be the average of not less than 5 tests made from different batches preferably on different days.)
5. Absorption of water.
6. Specific gravity.

Coarse Aggregate.—

1. Sieve analysis.
2. Unit weight.
3. Absorption of water.
4. Specific gravity.

    The voids in aggregate may be calculated from the specific gravity and the unit weight.

Concrete.—

1. Compression tests of 6 by 12-in. cylinders at 28 days.
2. Unit weight.
3. Density.
4. Yield.

Sieve Analysis of Fine Aggregates.—Use a 500-g. sample in a room-dry condition. Tests may be made by hand or by machine. Use 8-in. woven wire from the "Tyler Standard Screen Scale" having 100, 48, 28, 14, 8 and 4 square meshes per linear inch. Sifting should be continued until the quantity passing any sieve in 1 minute additional shaking does not exceed

1 per cent of the weight of the original sample. The balance used for weighing should be accurate to less than 1 g. Make triplicate tests before using the values in calculating quantities of materials required for concrete tests.

Sieve Analysis of Coarse Aggregates.—Use a 5000-g. or 10-lb. sample in a room-dry condition. Tests can best be made by hand sifting, using 18-in. circular riddles equipped with sieves from the "Tyler Standard Screen Scale" having 4 meshes per linear inch and $\frac{3}{8}$, $\frac{3}{4}$ and $1\frac{1}{2}$-in. square openings. Sifting should be continued until the quantity passing any sieve in 1 minute additional sifting shall not exceed 1 per cent of the weight of the original sample. Make triplicate tests before using the values in calculating quantities.

Method of Recording Sieve Analysis of Aggregates.—The sieve analysis of the aggregates may be recorded as:

1. Percentage of total weight of original sample *coarser than* each sieve.
2. Percentage of total weight of original sample *finer than* each sieve.
3. Percentage of total weight of original sample *between* two adjacent sieves.

The sieve analysis expressed in one form can readily be converted to either of the other forms.

Measure of the Size and Grading of Aggregates.—Three different methods of measuring the size and grading of aggregate have been used or proposed:

1. Fineness modulus.
2. Surface area.
3. Surface modulus.

The Fineness Modulus is a logarithmic function of the diameter of the particle. It is most conveniently derived from the sieve analysis when expressed as percentages of the total weight of the sample *coarser than* each sieve. With the sieve analysis expressed in this way, the fineness modulus may be defined as "the sum of the percentages in the sieve analysis of the aggregate divided by 100." The fineness modulus may be considered as an abstract number; it is in fact a summation of weighted percentages of aggregate, by weight or volume when divided into size zones by the standard sieves listed above. The coarser aggregates give high values and finer aggregates low values of fineness modulus. For further details, see "Design of Concrete Mixtures" by D. A. Abrams, *Bulletin 1*, Structural Materials Research Laboratory.

The Surface Area is a function of the square of the diameter of the aggregate particles. It does not necessarily represent the actual surface area. The surface area has been used in two different ways in dealing with concrete mixtures:

(*a*) Grams of cement per 1000 sq. in. of surface area of aggregate.

(*b*) Square inches of surface area of aggregate per gram of cement.

The surface area can best be calculated from the sieve analysis when expressed as percentages of the weight of material *between* two adjacent sieves. Diagrams have been worked out by L. N. Edwards,[1] based on actual count of sand particles for use in calculating the surface areas of aggregate of a given size or grading.

The Surface Modulus is a function of the square of the diameter of the particle. It is a modification of the surface area method of measuring the size and grading of aggregates.

If p_1 represents the percentage passing the 100-mesh sieve, p_2 that between the 100 and the 48-mesh sieve, p_3 . . . the corresponding percentages between the other pairs of adjacent sieves up to the largest size of particle, then the sum

$$S = p_1 + \tfrac{1}{2}p_2 + \tfrac{1}{4}p_3 + \tfrac{1}{8}p_4 + \ \ldots\ + \tfrac{1}{64}p_7 + \tfrac{1}{128}p_8 + \tfrac{1}{256}p_9$$

will be proportional to the surface area of all the particles (if there is little material finer than the 200-mesh sieve), and may be termed the *surface modulus*. This method requires that the sieve analysis be expressed as percentages of material *between* two adjacent sieves. A more complete description of this method will be found in Professor A. N. Talbot's discussion published in the *Proceedings*, Am. Soc. Test. Mats., Vol. XIX, Part II, p. 481 (1919).

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[1] L. N. Edwards, "Effects of Grading of Sand and Consistency of Mix upon the Strength of Plain and Reinforced Concrete," *Proceedings*, Am. Soc. Test. Mats., Vol. XVII, Part II, p. 302 (1917).

L. N. Edwards, "Proportioning the Materials of Mortars and Concretes by Surface Areas of Aggregates," *Proceedings*, Am. Soc. Test. Mats., Vol. XVIII, Part II, p. 235 (1918).

Combinations of Fine and Coarse Aggregates.—The fineness modulus of a mixture of two aggregates may be calculated as follows:

$$m = p_f\, m_f + p_c\, m_c$$

where, m, m_f and m_c = the fineness modulus of the mixed, fine and coarse aggregates and p_f and p_c = the volumes of fine and coarse aggregates respectively expressed as percentages of the sum of the separate volumes of the fine and coarse aggregates.

The same formula may be used for calculation of the *surface area* or *surface modulus* of a mixed aggregate. This method is not exact, but the error is slight and is of no importance here.

Colorimetric Test for Organic Impurities.—This test should be made on the sands used in the tests. The test may be made by shaking the sand thoroughly in a dilute solution of sodium hydroxide (NaOH) and observing the color of the liquid after the mixture has been allowed to stand for a few hours. Fill a 12-oz. graduated prescription bottle to the $4\frac{1}{2}$-oz. mark with the sand to be tested. Add a 3-per-cent solution of sodium hydroxide until the volume of the sand and solution, after shaking, amounts to 7 oz. Shake thoroughly and let stand for 24 hours. Observe the color of the clear liquid above the sand. A good idea of the quality of the sand may be formed earlier than 24 hours, although this period is believed to give best results. If the solution resulting from this treatment is colorless or has a light yellowish or straw color, the sand may be considered satisfactory in so far as organic impurities are concerned. On the other hand, if a dark-colored solution is produced, the sand should be rejected.

The foregoing description is from the appendix to the last annual report of Committee C-9 on the "Abrams-Harder Field Test for Organic Impurities in Sands."[1]

An approximate measure of the volume of silt in the sand may be secured by observing the depth of fine material at the top of the sand sample after completing the colorimetric test.

Unit Weight of Aggregates.—Triplicate tests should be made on all fine, coarse, and mixed aggregates before beginning proportioning of batches. Use a cylindrical metal measure having an inside diameter equal to inside depth. A measure of capacity $\frac{1}{5}$ to $\frac{1}{2}$ cu. ft. may be used for fine, coarse or mixed aggregate so long as the coarse aggregate does not exceed 2 in. in size. For coarse aggregate graded in sizes above 2 in., measures of $\frac{1}{2}$ to 1 cu. ft. capacity should be used. A measure as small as $\frac{1}{20}$ cu. ft. may be used for fine aggregate.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XIX, Part I, p. 321 (1919).

Fill measure one-third full, puddle with 25 to 30 strokes from a $\frac{5}{8}$-in. round steel bar, 21 in. long, pointed at the lower end. Continue filling and puddling in like manner until measure is full, then strike off top by a rolling motion with the bar. Determine the weight of contents of measure and calculate the weight in pounds per cubic foot.

This method is the one recommended by Sub-Committee VI of Committee C-9 after an exhaustive study of the subject.[1] It will be noted that the method of filling the measure is similar to that used in molding the cylinders for compression tests of concrete, and in the slump test for plasticity.

An important advantage of this method of determining unit weight is that for mixed aggregates as used in ordinary mixtures, it gives a quantity of aggregate which closely approximates that required for a unit volume of finished concrete.

Mortar Strength Tests of Fine Aggregate.—Two forms of specimens should be made using 1:3 mortar mixtures *by weight* and *by volume* as follows:

1. Briquettes for tension test at 7 and 28 days.
2. Cylinders, 2 by 4-in., for compression tests at 7 and 28 days.

Mortar tests are generally made on mixtures proportioned *by weight*. This is not a proper basis when comparison is being made between fine aggregates of widely different characteristics. A fine sand is unduly penalized as compared with a coarse sand if mixed by weight. Volumetric proportions are used in field work in concrete; hence they should also be used in laboratory tests.

All mortar should be mixed to the same plasticity as that required for standard sand mortars.

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[1] See the Tentative Test for Unit Weight of Aggregate, p. 624.

The following procedure is recommended: Mix sufficient mortar in a batch for 2 briquettes and 2 cylinders; mark one specimen of each kind for test at 7 and the other at 28 days. Repeat for 5 different batches. The average of the 5 tests is reported as the result of mortar strength tests on given samples of cement and fine aggregate. The standard sand mortar tests should be made at the same time. Make *triplicate* mortar strength tests during the period covered by the concrete tests.

Briquettes should be mixed, molded, stored and tested in the same way as in standard sand mortar tests.

Two-by-four-inch cylinders should be molded in metal forms using a plate glass or machined metal base and capped with plate glass in the same manner as in concrete tests described below.

Store all mortar test pieces in water at 65 to 70° F. until ready to place in the testing machine.

Absorption of Aggregates.—It is necessary to determine the absorption of the aggregate in order that proper allowance may be made for this factor in proportioning the mixing water. Experience has shown that the absorption after a 3-hour immersion in water gives the most useful results.

Absorption Test of Fine Aggregate.—Dry aggregate to constant weight. Select duplicate 500-g. samples *A* and *B*. (A sampler should be used for this purpose.) Place each sample in a 500-cc. volumetric flask. Thoroughly mix sample *A* with about 20 cc. of kerosene by shaking the flask. Determine the volume of a normal salt solution (58 g. NaCl per liter of water) required to fill flask to the 500-cc. mark. (The surplus kerosene will float on top of the salt solution and the line of separation can be read. It will sometimes be found necessary to add 5 to 10 drops of ether to disperse kerosene globules.) This determination gives the absolute volume of 500 g. of dry sand. This volume may be used for calculating the specific gravity of the fine aggregate.

Introduce in flask *B* a measured quantity of water sufficient to cover the aggregate; shake thoroughly at intervals. Three hours after adding the water, determine the volume of water necessary to fill to the 500-cc. mark. The absorption expressed as a ratio to weight of aggregate may be calculated by subtracting the volume of salt solution used for sample *A* from the total volume of water used for sample *B* and dividing by the dry weight of the aggregate. The absorption expressed as a ratio to volume of aggregate is obtained by multiplying the absorption by weight by the weight per cubic foot of the sand and dividing by 62.5.

Absorption Test of Coarse Aggregate.—Dry sample to constant weight. Immerse in clean water at room temperature. After a three-hour immersion remove the aggregate from the water and surface-dry by rolling in a dry cloth and weigh. Weights should be accurate to 0.1 per cent. The absorption expressed as a ratio to weight of aggregate is determined by subtracting the dry weight from the wet weight and dividing by the dry weight. The absorption expressed as a ratio to volume of aggregate is obtained by multiplying the absorption by weight by the weight per cubic foot of the aggregate and dividing by 62.5.

Determine the weight of the saturated coarse aggregate immersed in water for the purpose of calculating its specific gravity. The apparent specific gravity of the aggregate is desired for use in calculating the density and voids in the aggregate.

Unit Weight of Concrete.—The weight of the concrete in pounds per cubic foot should be accurately determined from the weight of the specimens and their dimensions. The concrete cylinders should be weighed immediately upon removal of the forms.

The Density and Yield of Concrete should be calculated from the weight per cubic foot and density of the cement and aggregate and the weight per cubic foot of the concrete. Density is understood to refer to the total solids in the mass. Yield is based on the volumes of concrete produced by 1 volume of aggregate mixed as used. If the concrete contains an excess of free water this fact must be taken into account in calculating density and yield.

QUANTITY OF MIXING WATER IN CONCRETE.

The quantity of mixing water exerts an important influence on the strength and other properties of concrete. The concrete must be plastic in order that it may be molded to the desired outlines and placed around the reinforcing members. The addition of water to a concrete already plastic is known to reduce the strength. Concretes of different proportions or from different materials must be mixed to a uniformly plastic condition in order that they may be directly comparable. The quantity of water necessary for concrete is a function of the following:

1. Relative plasticity of concrete required.
2. Quantity of cement (the mixture).
3. Size and grading of aggregate.
4. Normal consistency of cement.
5. Absorption of aggregate.
6. Water contained in aggregate.

For the purpose of studying the effect of varying the quantity of mixing water, a graduated range of consistencies is used in Series 201.

It is convenient to refer to the quantity of water in the batch in terms of (1) the relative consistency and (2) the water-cement ratio. The plastic condition of the concrete may be measured by means of the slump test for plasticity.

Relative Consistency refers to the plastic condition of the concrete regardless of the quantity of water used. A relative consistency of 1.00 should be such as will give a slump of $\frac{1}{2}$ to 1 in. and may be referred to as *Normal Consistency*. A relative consistency of 1.10 contains 10 per cent more water and a relative consistency of 0.90 contains 10 per cent less water than that required for normal consistency, etc. A relative consistency of 1.00 to 1.20 represents about the driest concrete that can be ordinarily used in construction work.

Water-Cement Ratio is the ratio of volume of water to volume of loose cement in the batch after making allowance for the water absorbed by the aggregate. This function is convenient in studying the strength and other properties of concrete of different proportions. The distinction between relative consistency and water-cement ratio should not be overlooked. The relative consistency refers to the *plastic condition* of the concrete without reference to the quantity of water; the water-cement ratio takes account of the *quantity of water* as compared to the cement, without regard to the plastic condition of the concrete. The water-cement ratio may be expressed in terms of gallons of water per sack (94 lb. = 1 cu. ft.) of cement.

Slump Test for plasticity.—The committee recommends the use of a metal form in the shape of a truncated cone 4 in. in top diameter, 8 in. in bottom diameter and 12 in. high for the slump test. The slump test is made by molding the concrete in the same manner as in molding cylinders for compression tests. Place the concrete in 3 layers, approximately 4 in. in thickness. Puddle each layer with 25 to 30 strokes from a $\frac{5}{8}$-in. round steel bar 21 in. long, pointed at the lower end. Immediately after molding, remove the form by a steady upward pull. Measure the height of the resulting concrete in inches; this value subtracted from 12 in. is the "slump." If desired, duplicate slump tests may be made by other methods. After the slump test, the same concrete is remolded into a 6 by 12-in. cylinder for the compression test.

CONCRETE TEST PIECES.

Size.—All of the concrete tests in Series 201 will be made on 6 by 12-in. cylinders.

Molds.—The molds should be of metal. The best type of mold consists of a 12-in. length of cold drawn steel tubing 6 in. in inside diameter, split along one element and closed by means of a circumferential band and bolt. Satisfactory forms can be made from lengths of steel water pipe machined on the inside, from rolled metal plates, or from galvanized steel. Particular care should be taken to obtain tight forms so that the mixing water will not escape during molding. Each form should be provided with a machined metal base plate.

For the mixtures of the higher consistencies it will be necessary to seal the bottom and vertical joint in the form by means of hot paraffin applied with a paint brush, in order to prevent loss of water.

Order of Making Specimens.—Each set of tests is to consist of 5 cylinders. One cylinder of each kind should be made before beginning the second round. In this way the 5 tests in a set will be made on different days and the values reported will be the average of 5 independent tests. This method serves to eliminate the effect of accidental variations which would affect the results of some of the tests, if all the specimens in a set were made on the same day or from a single batch.

PROPORTIONING AND MIXING CONCRETE.

Proportioning.—All concrete will be proportioned by volume: that is, one volume of cement to a given number of volumes of mixed aggregate. The exact quantities of materials to be used in the batch should be determined by weight, considering cement to weigh 94 lb. per cu. ft. The required quantities of each size of aggregate can be determined on the basis of the unit weights of the final mixed aggregates.

The fine aggregate may be used without screening, except as required in Group A. In general, material coarser than the No. 4 sieve should be removed from fine aggregate in the other group of tests. The aggregate in the pile or bin should be turned over at intervals in order to prevent segregation.

The coarse aggregate should be screened to the following sizes:

No. 4 to $\frac{3}{8}$ in., $\frac{3}{8}$ to $\frac{3}{4}$ in., $\frac{3}{4}$ to $1\frac{1}{2}$ in.,

and remixed in the proportions required to secure approximately the original sieve analysis.

Mixing.—The concrete should be mixed by hand in small batches of sufficient size to make a single specimen. This will required about $\frac{1}{5}$ cu. ft. The batch can best be mixed in a shallow galvanized iron pan with a 10-in. bricklayer's trowel which has been blunted by cutting off about $2\frac{1}{2}$ in. of the point. Each batch should be thoroughly mixed dry, then mixed after adding water until the entire mass is homogeneous in appearance.

MOLDING, CAPPING AND STORING TEST CYLINDERS.

Molding.—The specimens should be molded by placing the concrete in the form in 3 layers, approximately 4 in. in thickness. Each layer should be puddled with 25 to 30 strokes with a $\frac{5}{8}$-in. round steel bar, 21 in. long, pointed at the lower end. After puddling the top layer, clean off the surplus concrete with a trowel, and cover with a piece of plate glass which will be used later in capping the specimens.

Capping Cylinders.—Two to four hours after molding, cap the specimens with a thin layer of stiff neat cement paste in order that the cylinder may present a smooth end for loading. The cap can best be formed by means of a piece of plate glass ($\frac{1}{4}$ in. thick, 7 to 8 in. square) which is worked down on the fresh cement paste until it rests on the top of the form. The cement for capping should be mixed to a stiff paste before beginning of the day's work of making the concrete specimens. In this way the tendency of the cap to shrink will be largely eliminated. The adhesion of the concrete to the metal base plate and the glass can be largely eliminated by oiling the plate glass and by inserting a sheet of paraffined tissue paper.

Storage of Concrete Cylinders.—The specimens should be removed from the form on the following day, marked, weighed and stored in damp sand or in a moist chamber until the date of test. All tests should be made with the specimens in a damp condition.

Age at Test.—Since there is a well-established relation between strength and age of concrete for given conditions of storage, it is believed that tests at one age are sufficient. All concrete tests in Series 201 will be made at the age of 28 days.

METHODS OF TESTING CONCRETE CYLINDERS.

In general only the ultimate compressive strength of the cylinders need be observed. It would add considerably to the value of the tests if stress-deformation relations were determined, from which the modulus of elasticity would be calculated.

The moving head of the testing machine should travel at the rate of about 0.05 in. per minute when the machine is running idle.

Place the bearing plates of the testing machine directly in contact with the ends of the specimens: that is, do not use blotting paper or other cushioning material.

Use a spherical bearing block on *top* of the specimen. The diameter of the bearing block should be approximately the same as that of the specimen. Keep the upper section of the adjustable block in motion as the head of the testing machine is brought to a bearing. This insures a central bearing and prevents the cylinder being pulled aside, which frequently occurs when the block is allowed to adjust itself.

REPORT OF TESTS.

Complete information should be furnished on all details of the tests, constituent materials and concrete referred to above. The results of the tests in Series 201 should be reported promptly to the committee. These tests will be incorporated in the published report of the committee.

Correspondence with reference to Series 201 should be addressed to

D. A. ABRAMS,
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Chicago, Ill.

COOPERATIVE TESTS OF CONCRETE: SERIES 201

OUTLINE OF TESTS.

(7TH REVISION, FEBRUARY 3, 1920.)

This series of tests (see Table I) constitutes a study of the effect of size and grading of aggregates, quantities of mixing water and cement on the strength of concrete. These tests will furnish a basis for comparing different proposed methods of designing concrete mixtures.

Compression tests of 6 by 12-in. cylinders.

Mix by volume.

Concrete for each specimen to be proportioned and mixed separately by hand.

The 5 cylinders in a set to be made on different days.

Aggregates: local materials mixed in a room-dry condition. A commercial sand is to be used. The coarse aggregate should be graded from No. 4 to 1¼ or 2 in.

Portland cement: a mixture of equal parts of 3 or more local brands.

Normal consistency of concrete (relative consistency = 1.00) is based on the use of such a quantity of mixing water as will cause a slump of ½ or 1 in. in a freshly molded 4 by 8 by 12-in. frustum of a right circular cone upon withdrawing the form immediately after molding. If desired, duplicate slump tests may be made by other methods.

Cap cylinders with neat cement 2 to 4 hours after molding.

Store specimens in damp sand or saturated atmosphere; test damp.

Age at test: 28 days.

Details of methods of selecting and testing constituent materials, proportioning and mixing batches, making specimens and tests, will be found in the foregoing "Outline of Compression Tests of Concrete for Investigation of Properties of Concrete Mixtures," prepared by Committee C-9.

TABLE I.—OUTLINE OF TESTS.

Group No.	Aggregate.				Mix by Volume.	Relative Consistency.	Total Number of Specimens (5 in each set).
	Kind.	Size.		Fineness Modulus.			
		Fine.	Coarse.				
1	Sand and Pebbles	Commercial Sand (medium)	No. 4 to $1\frac{1}{2}$ in.	(x) 4.50 5.50 5.75 6.00 6.25 6.50	1 : 7 1 : 5 1 : $3\frac{1}{2}$	0.80 0.80 1.00 1.10 1.25 1.50	630
2	Sand and Crushed Stone	Commercial Sand					630
3	Sand and Crushed Slag	Commercial Sand					630
4	Stone Screenings and Crushed Stone	Commercial Screenings					630
A[1]	....	Fine Coarse	No. 4 to $1\frac{1}{2}$ in.	(x) 4.50 5.50 5.75 6.00 6.25 6.50	1 : 5	0.80 0.90 1.00 1.10 1.25 1.50	420

[1] Group A may be included as supplementing any one or more of the other groups. The two fine aggregates in this group, together with the fine aggregate in the major group selected, should form a graduated series of finenesses which may be characterized as "fine," "medium" and "coarse." All fine aggregates in this case should be screened from the same lot of material.

The different values of "fineness modulus" of the mixed aggregate are to be obtained by mixing the fine and coarse aggregate in proportions which will produce the values shown. In discussing the tests "surface area" or "surface modulus" may be substituted for "fineness modulus" as a measure of the size and grading of aggregate. The fineness modulus marked (x) refers to the value of the fine aggregate only.

It is desired that each laboratory cooperating in this work shall make at least one group complete. The group or groups should be decided upon after consultation with the chairman of the committee. As many groups as possible should be tested by each laboratory.

APPENDIX II.

EFFECT OF TANNIC ACID ON THE STRENGTH OF CONCRETE.

By Duff A. Abrams.

Summary.

It has long been recognized that impurities of an organic nature have the effect of reducing the strength of concrete or entirely destroying the hydraulic properties of the cement. While this fact has been pointed out by a number of writers, there is still a tendency among concrete engineers to disregard the effect of such impurities. A general investigation of this subject was inaugurated in 1915 by means of funds furnished by Committee C-9 on Concrete and Concrete Aggregates and has been continued during the past four years as a part of the investigations being carried out through the cooperation of Lewis Institute and the Portland Cement Association.

It was impossible to secure natural sands containing graduated percentages of organic impurities for a study of the *quantitative* effect of such impurities. Consequently, we prepared aggregate samples in which known quantities of organic impurities were present, by applying tannic acid as a surface coating in quantities up to 0.40 per cent by weight. Compression tests were made on 3 by 6-in. concrete cylinders. The mix varied from 1:5 to 1:2; the size of aggregate ranged from a fine sand to a $\frac{3}{4}$-in. graded aggregate. Tests were made on all mixtures and sizes of aggregate at ages of 7 days, 28 days, 3 months, 1 year, and 2 years. Specimens were stored in damp sand. This series included about 2000 concrete tests.

Following are the principal conclusions from this investigation:

1. It is believed that the results of these tests are, in general, typical of the effect produced by organic impurities in

concrete, judging from tests with natural sands containing organic matter, made in Lewis Institute and other laboratories.

2. The strength of concrete was reduced for all percentages of tannic acid, for all mixes and ages covered by these tests. Less than 0.1 per cent of tannic acid in terms of the weight of the aggregate may reduce the strength of the concrete to one-half its normal value.

3. Lean mixtures are more affected by tannic acid than the rich ones.

4. The mixtures from the finer aggregates are less affected by tannic acid than those from the coarser aggregates.

5. All of the effects mentioned above may be summed up by saying that the reduction in strength of concrete is a function of the *concentration* of tannic acid in the mixing water. An equation is given which represents this relation for the 28-day tests.

6. The results of these tests indicate that the wetter consistencies would be less affected by the presence of organic impurities than the drier ones.

7. The strength falls off rapidly for small percentages of tannic acid and less rapidly as higher percentages are reached.

8. The 7 and 28-day strengths are reduced to a greater extent by tannic acid than at ages of 1 and 2 years.

9. Some of the 1:5 mixes in which the higher percentages of tannic acid and the finer sands were used (2 to 3-per-cent solution) disintegrated before the time of test. The 1:7 mixes (3 to 5-per-cent solution) were destroyed in removing the molds.

10. The tests confirm the results of many other investigations made in this Laboratory in showing the fundamental dependency of strength of concrete on the quantity of mixing water as expressed by the water-ratio.

11. The strength of concrete (stored in a damp place) both with and without tannic acid increased with age. The strength for a given condition was a logarithmic function of the age.

Care should be taken to eliminate surface loam from concrete sands. Loam can generally be removed by washing.

Attention is called to the "colorimetric" test with sodium hydroxide as a convenient method of testing for organic impurities in natural sands.

INTRODUCTION.

It has long been recognized that organic impurities are injurious in sands used for both cement and lime mortars. Contamination from surface loam and the presence of other organic materials peculiar to local conditions are the principal sources of organic impurities in sands. Many specifications for concrete aggregate require that the sand be clean, but definite information has been lacking as to the exact effect of organic impurities on concretes of widely different composition.

The necessity for clean sand was fully appreciated by the ancients as shown by the following extract from "A Treatise on Architecture," by Vitruvius, a Roman architect and engineer; written about 100 B. C.:

> "In buildings of rubble work it is of the first importance that the sand be fit for mixing with the lime and unalloyed with earth." (Book 1, Chapter 4.)

Many modern writers have pointed out the injurious effect of organic materials in concrete. However, in spite of the numerous warnings, there is a tendency to disregard the dangers which lie in the use of sands containing organic impurities which may come from contamination of surface loam and other foreign material.

The U. S. Department of Agriculture reports (Bulletin 47, Bureau of Soils) that the ordinary top soil contains on the average over 2 per cent of organic matter. This value is based on many thousand tests on samples from all sections of the country. In many instances the organic material is much higher than 2 per cent. The sub-soil for several feet in depth contains an appreciable percentage of organic material.

A general investigation of the whole subject of the effect of organic impurities on mortars and concretes was begun at Lewis Institute, in 1915, by means of funds appropriated by Committee C-9 on Concrete and Concrete Aggregates. The earlier investigations covered the study of the concrete-making properties of natural sands containing organic impurities of such a nature as to be injurious to concrete. A preliminary report under the title of "Colorimetric Tests for Organic Impurities in

Sands"[1] was published in 1917. That report indicated a method of testing for organic impurities which consists of digesting a sample of the sand in a dilute solution of sodium hydroxide and observing the color of the resulting liquid.

Later investigations of the effect of organic impurities have been conducted as a part of the experimental studies of concrete and concrete materials being carried out through the cooperation of Lewis Institute and the Portland Cement Association at the Structural Materials Research Laboratory. The tests covered by this report were made under the immediate supervision of Dr. Oscar E. Harder, former Research Chemist in this laboratory.

In this investigation it was necessary to use an artificially prepared sand, due to the fact that no natural sands could be found which contained graduated percentages of organic impurities in sufficient quantities to enable us to investigate the *quantitative* effect of such material in concrete of different mixtures made up of aggregate of different size, tested at different ages, etc. The characteristic compounds which are commonly found to be injurious in natural sands are of a humous nature—frequently tannates of some form. This condition suggested the use of tannic acid as a means of conducting further studies of the effect of organic impurities on the strength and other properties of concrete. It is believed that the results secured from this study may be considered typical of the effect of organic impurities in natural sands.

OUTLINE OF TESTS.

This investigation comprised compression tests of 2000 3 by 6-in. cylinders made of concrete[2] from sand and pebbles of different sizes, ranging from 0 – No. 28-sieve sand to 0 – $\frac{3}{4}$-in. aggregate. In each instance the tannic acid content was varied up to 0.40 per cent of the weight of the aggregate.

The following table shows the variables covered by the tests:

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[1] Appendix II, Report of Committee C-9, *Proceedings*, Am. Soc. Test. Mats., Vol. XVII, Part I, p. 327 (1917).

See also "Abrams-Harder Field Test for Organic Impurities in Sands," Report of Committee C-9, *Proceedings*, Am. Soc. Test. Mats., Vol. XIX, Part I, p. 321 (1919).

[2] Concrete is here used in its general sense to include what are generally considered mortar mixtures.

SIZE OF AGGREGATE.	MIX BY VOLUME.	TANNIC ACID, PER CENT BY WEIGHT OF AGGREGATE.	AGE AT TEST.
0 to No. 28	1 : 5	0.0	7 days
0 to No. 14	1 : 4	0.05	28 days
0 to No. 8	1 : 3	0.10	3 months
0 to No. 4	1 : 2	0.20	1 year
0 to $\frac{3}{8}$ in.		0.40	2 years
0 to $\frac{3}{4}$ in.			

All possible combinations of the above factors were used in this investigation. Each strength value is based on four tests made on different days at intervals of two to three weeks. In other words each value is the average of four entirely independent tests.

TABLE I.—MISCELLANEOUS TESTS OF CEMENT.

A mixture of equal parts of four brands of Portland cement, purchased in the Chicago market.
All tests were made in accordance with the standard methods of the American Society for Testing Materials.
Each value is the average of two tests.

Fineness Residue on No. 200 Sieve.	Normal Consistency, per cent. by Weight.	Time of Setting.								Soundness Test Over Boiling Water.
		Vicat Needle.				Gillmore Needle.				
		Initial.		Final.		Initial.		Final.		
		h.	m.	h.	m.	h.	m.	h.	m.	
18.8	23.0	3	40	7	40	5	15	8	30	OK

The original plan called for a 1:7 mix, but it was found impracticable to handle the specimens containing tannic acid, consequently this mix was dropped.

Materials.—The Portland cement used in this investigation consisted of a mixture of equal parts of four brands purchased in the Chicago market. Lots of one sack of each brand of cement were thoroughly mixed dry in a concrete mixer before it was used. Miscellaneous tests of cement are given in Table I. Compression and tension tests of standard sand mortar at ages up to two years are given in Table II.

The aggregates consisted of different sizes of sand and pebbles from the Elgin, Ill., pit of the Chicago Gravel Company. The material was largely of limestone origin. Sieve analysis of the aggregates is given in Table III. The "fineness modulus"[1] of the aggregate is used as a measure of its size and grading. It is the sum of the percentages in the sieve analysis divided by 100. The sieve analysis is expressed in terms of the percentages by weight *coarser than* the sieves shown. The sieves are from the standard screen scale series of The W. S. Tyler Co., Cleveland, Ohio.

The tannic acid used was of commercial grade in crystal form. It was dissolved in water and applied in small increments to the sand by sprinkling a known solution over the sand and mixing thoroughly. The sand was allowed to dry at a low temperature before another application was made. Tannic acid was added as a surface coating in this way to the amount of 0.05, 0.10, 0.20 and 0.40 per cent of the weight of the aggregate. The sands thus prepared responded to the "colorimetric test" with sodium hydroxide described below.

TABLE II.—MORTAR STRENGTH TESTS.

1 : 3 Standard sand mortar. Stored in water; tested wet. Each value is the average of 5 tests made on different days.

Mixing Water, per cent.	Briquettes. Tensile Strength, lb. per sq. in.						2 by 4-in. Cylinders. Compressive Strength, lb. per sq. in.					
	7 d.	28 d.	mo.	6 mo.	1 yr.	2 yr.	7 d.	28 d.	3 mo.	6 mo.	1 yr.	2 yr.
10.3	242	378	462	440	387	369	1770	3360	4380	4570	4490	4650

The water used was from the city supply obtained from Lake Michigan.

Test Pieces.—All tests were made on 3 by 6-in. cylinders. The concrete was mixed by hand in batches of sufficient size to make 4 specimens. One specimen from each batch was tested at 7 days, 28 days, 3 months, 1 year, and 2 years. The specimens were molded in metal forms consisting of 6-in. lengths of cold-drawn steel tubing which was split along one element and closed by means of a circumferential band. The concrete was placed in the form in 3 or 4 layers; each layer being puddled with a small steel bar. The different mixtures and sizes of aggregate were mixed to the same consistency. One batch of each kind was mixed before starting on the second round.

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[1] For further details see "Design of Concrete Mixtures" by Duff A. Abrams, *Bulletin 1*, Structural Materials Research Laboratory, Lewis Institute, Chicago.

The forms were removed on the day following molding. The specimens were stored in damp sand until the time of test.

DATA OF TESTS.

The data of the concrete tests are given in Tables IV and V. Each value for concrete strength is the average of four independent tests made on different days. In Table VI the strengths of concrete containing tannic acid have been reduced to percentages of the strength of similar concrete without tannic acid and tested at the same age; in this table the tannic acid is given in terms of the mixing water (per cent concentration). Most of the results are given in graphical form in Figs. 1 to 16.

TABLE III.—MISCELLANEOUS TESTS OF AGGREGATE.

Sand pebbles from Elgin, Ill.
The sieves used were from the "Standard Screen Scale," manufactured by The W. S. Tyler Co., Cleveland

Size of Aggregate.	Weight, lb. per cu. ft.	Sieve Analysis. Per Cent Coarser than Each Sieve.								Fineness Modulus.[1]
		100	48	28	14	8	4	$\frac{3}{8}$-in.	$\frac{3}{4}$-in.	
0 to No. 28	100	97	76	0	.....	.....	.....	.....	.....	1.73
0 to No. 14	104	98	84	33	0	.....	.....	.....	.....	2.15
0 to No. 8	110	98	86	49	22	0	.....	.....	.....	2.55
0 to No. 4	115	99	88	58	35	20	0	.....	.....	3.00
0 to $\frac{3}{8}$ in	120	99	91	70	52	36	20	0	.....	3.68
0 to $\frac{3}{4}$ in	127	99	93	75	60	52	40	22	0	4.40

[1] Sum of the percentages in sieve analysis, divided by 100.

The unit weight of the concrete upon removal of the forms is given in Table VII.

DISCUSSION OF TESTS.

The methods followed in making these tests gave consistent results throughout the series. While it is impracticable to deal with one phase of this subject to the exclusion of all others, the results of the tests will be discussed under a number of different

TABLE IV.—EFFECT OF TANNIC ACID ON THE STRENGTH OF CONCRETE.
(Mixes 1 : 2 and 1 : 3)

Compression tests of 3 by 6-in. concrete cylinders.
Aggregate: sand and pebbles from Elgin, Ill.
Hand-mixed concrete. Relative consistency, 1.00.
Specimens were mixed 5 in a batch, one for test at each age.
In general, each value is the average of 4 tests made on different days.

Aggregate.		Mix, 1 : 2 by Volume.							Mix, 1 : 3 by Volume.						
Size.	m.[1]	Water-Ratio.	Compressive Strength, lb. per sq. in.						Water-Ratio.	Compressive Strength, lb. per sq. in.					
			7 d.	28 d.	3 mo.	1 yr.	2 yr.	Average.		7 d.	28 d.	3 mo.	1 yr.	2 yr.	Average.
0.0 PER CENT TANNIC ACID.															
0 to No. 28	1.73	0.77	1050	2170	3200	3800	4500	2940	0.98	610	1220	2280	2300	3730	2030
0 to No. 14	2.15	0.74	1150	2410	2870	3440	4740	2920	0.94	800	1640	2430	3150	4080	2420
0 to No. 8	2.55	0.71	1370	2630	3780	4580	4700	3410	0.89	890	1840	2790	3500	4180	2640
0 to No. 4	3.00	0.69	1600	3270	4050	5040	5600	3910	0.86	1090	2230	3860	4340	5100	3320
0 to ⅜ in.	3.68	0.65	1910	3700	5140	5310	5830	4380	0.80	1440	2860	4620	4850	5570	3870
0 to ¾ in.	4.40	0.60	2100	3910	5020	4870	5450	4270	0.73	1600	3340	4690	5150	6030	4160
Average	......	......	1530	3020	4010	4510	5140	3640	......	1070	2220	3440	3880	4780	3070
0.05 PER CENT TANNIC ACID.[2]															
0 to No. 28	1.73	0.77	1050	2040	3510	3960	4350	2980	0.98	580	1250	2000	2620	3300	1950
0 to No. 14	2.15	0.74	1200	2390	3640	4660	4640	3310	0.94	660	1350	2190	2960	3640	2160
0 to No. 8	2.55	0.71	1200	2370	3730	4200	4400	3180	0.89	740	1490	2380	3330	3870	2360
0 to No. 4	3.00	0.69	1370	3000	3880	4290	5100	3530	0.86	940	1990	3060	3830	4650	2890
0 to ⅜ in.	3.68	0.65	1520	2620	4070	4470	5600	3660	0.80	1010	2240	3290	4110	4740	3080
0 to ¾ in.	4.40	0.60	1640	2770	3940	4070	5000	3480	0.73	1160	2350	3570	3720	4760	3110
Average	......	......	1330	2530	3800	4270	4850	3360	......	850	1780	2750	3430	4160	2590
0.10 PER CENT TANNIC ACID.[2]															
0 to No. 28	1.73	0.77	880	1880	3170	3470	4290	2740	0.98	450	1010	1460	2380	2880	1640
0 to No. 14	2.15	0.74	920	1960	3370	3790	4500	2910	0.94	600	1330	1920	2670	3140	1930
0 to No. 8	2.55	0.71	990	2180	3350	3990	4820	3070	0.89	630	1420	2030	2490	3560	2030
0 to No. 4	3.00	0.69	1080	2120	3560	2870	4640	2850	0.86	570	1270	2380	3120	3480	2160
0 to ⅜ in.	3.68	0.65	1410	2700	4090	4120	5510	3570	0.80	820	1870	2960	3450	4160	2650
0 to ¾ in.	4.40	0.60	1360	2830	3940	4120	5320	3510	0.73	890	2000	3070	3140	4500	2720
Average	......	......	1110	2280	3580	3730	4850	3110	......	660	1480	2300	2870	3620	2190
0.20 PER CENT TANNIC ACID.[2]															
0 to No. 28	1.73	0.77	720	1570	2790	3120	4230	2490	0.98	340	820	1280	1930	2400	1350
0 to No. 14	2.15	0.74	850	1650	2520	3540	3470	2410	0.94	440	1080	1650	2350	2850	1670
0 to No. 8	2.55	0.71	970	1880	2780	3810	4520	2790	0.89	420	1090	1590	2110	2720	1590
0 to No. 4	3.00	0.69	990	2000	3090	3640	4920	2930	0.86	500	1190	2020	2700	3490	1980
0 to ⅜ in.	3.68	0.65	1260	2420	3440	3670	3960	2950	0.80	600	1540	2340	2600	3740	2160
0 to ¾ in.	4.40	0.60	1250	2500	3220	3640	4580	3040	0.73	760	1460	2160	2730	3620	2150
Average	......	......	1010	2000	2970	3570	4280	2770	......	510	1200	1840	2400	3140	1820
0.40 PER CENT TANNIC ACID.[2]															
0 to No. 28	1.73	0.77	530	1370	2000	3300	3350	2110	0.98	90	540	730	1430	1860	930
0 to No. 14	2.15	0.74	680	1330	1890	2890	3200	2000	0.94	200	720	810	1440	1900	1010
0 to No. 8	2.55	0.71	660	1480	2220	3120	3860	2270	0.89	220	750	950	1410	2060	1080
0 to No. 4	3.00	0.69	920	1710	2680	3120	3690	2420	0.86	460	1120	1580	2200	3010	1670
0 to ⅜ in.	3.68	0.65	1180	2040	2720	3360	3970	2650	0.80	430	1130	1860	2620	3270	1860
0 to ¾ in.	4.40	0.60	1040	2130	2510	2920	3500	2420	0.73	500	1310	1940	2310	3100	1830
Average	......	......	840	1680	2340	5120	3600	2310	......	320	930	1310	1900	2530	1400

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[1] Fineness modulus of aggregate; see Table III.

[2] Table VI gives the *concentration* of tannic acid in terms of the weight of mixing water.

TABLE V.—EFFECT OF TANNIC ACID ON THE STRENGTH OF CONCRETE.
(Mixes 1 : 4 and 1 : 5)

Compression tests of 3 by 6-in. concrete cylinders.
Aggregates: sand and pebbles from Elgin, Ill.
Hand-mixed concrete. Relative consistency, 1.00.
Specimens were mixed 5 in a batch, one for test at each age.
In general, each value is the average of 4 tests made on different days.

Aggregate.		Mix, 1 : 4 by Volume.							Mix, 1 : 5 by Volume.						
Size.	m.¹	Water-Ratio.	Compressive Strength, lb. per sq. in.						Water-Ratio.	Compressive Strength, lb. per sq. in.					
			7 d.	28 d.	3 mo.	1 yr.	2 yr.	Average.		7 d.	28 d.	3 mo.	1 yr.	2 yr.	Average.
0.0 PER CENT TANNIC ACID.															
0 to No. 28	1.73	1.13	360	760	1410	1760	2480	1350	1.38	230	500	820	1390	1600	910
0 to No. 14	2.15	1.07	410	910	1600	2390	2600	1580	1.31	290	610	1040	1410	1630	1000
o to No. 8	2.55	1.00	460	1000	1700	2320	2660	1630	1.23	340	750	1170	1590	1970	1160
0 to No. 4	3.00	0.95	630	1270	2360	3200	3810	2250	1.18	450	920	1550	2140	2570	1530
0 to ⅜ in.	3.68	0.88	840	1700	3220	3390	4140	2660	1.09	570	1220	1920	2350	3300	1870
0 to ¾ in.	4.40	0.77	1080	2210	3440	3810	4990	3110	0.97	890	1770	2870	3430	4400	2670
Average	......	......	630	1310	2290	2810	3450	2100	......	460	960	1560	2050	2580	1520
0.05 PER CENT TANNIC ACID.²															
0 to No. 28	1.73	1.13	370	730	1290	1960	2260	1320	1.38	180	480	800	1010	1410	780
0 to No. 14	2.15	1.07	320	790	1520	1950	2520	1420	1.31	240	500	830	1300	1600	890
0 to No. 8	2.55	1.00	470	890	1680	2160	2450	1530	1.23	260	600	900	1490	1700	990
0 to No. 4	3.00	0.95	480	1180	2020	2700	3320	1940	1.18	350	710	1300	1880	2220	1290
0 to ⅜ in.	3.68	0.88	550	1330	2110	2950	3230	2030	1.09	380	970	1420	2090	2620	1500
0 to ¾ in.	4.40	0.77	780	1550	2690	3380	3840	2450	0.97	550	1200	2070	2450	3350	1920
Average	......	......	500	1080	1880	2520	2940	1780	......	330	740	1220	1700	2150	1230
0.10 PER CENT TANNIC ACID.²															
0 to No. 28	1.73	1.13	170	640	880	1530	1740	990	1.38	130	400	630	1090	1450	740
0 to No. 14	2.15	1.07	340	730	1280	1890	2230	1290	1.31	200	460	760	1100	1540	810
0 to No. 8	2.55	1.00	320	750	1360	2160	2580	1430	1.23	210	420	910	1180	1600	860
0 to No. 4	3.00	0.95	380	910	1730	2620	2720	1670	1.18	240	620	950	1440	1470	940
0 to ⅜ in.	3.68	0.88	560	1060	2020	3140	2600	1880	1.09	310	840	1320	1780	2460	1340
0 to ¾ in.	4.40	0.77	760	1170	2480	3030	2670	2020	0.97	500	1020	1660	1970	2290	1490
Average	......	......	420	880	1620	2390	2420	1550	......	260	630	1040	1430	1800	1030
0.20 PER CENT TANNIC ACID.²															
0 to No. 28	1.73	1.13	250	480	850	1680	1730	1000	1.38	130	320	460	750	1290	590
0 to No. 14	2.15	1.07	420	610	1030	1370	2030	1090	1.31	150	290	520	820	1030	560
0 to No. 8	2.55	1.00	470	840	1350	1770	2120	1310	1.23	170	460	580	1020	1280	700
0 to No. 4	3.00	0.95	300	940	1670	2140	2190	1450	1.18	250	370	680	800	1940	810
0 to ⅜ in.	3.68	0.88	360	930	1490	2140	2500	1480	1.09	200	490	890	1120	1650	870
0 to ¾ in.	4.40	0.77	380	970	2200	2660	2910	1820	0.97	240	670	1020	1490	2000	1080
Average	......	......	360	800	1430	1960	2250	1360	......	190	430	690	1000	1530	770
0.40 PER CENT TANNIC ACID.²															
0 to No. 28	1.73	1.13	310	540	700	1050	1560	830	1.38	70[a]	190[a]	780	610	1150	560
0 to No. 14	2.15	1.07	230	450	840	1030	1950	900	1.31	90	220	420	920	1190	570
0 to No. 8	2.55	1.00	140	480	910	1290	1820	930	1.23	80	210	440[a]	[a]850	1230[a]	560
0 to No. 4	3.00	0.95	340	1070	1520	1900	2780	1520	1.18	100	300	480	870	1260	600
0 to ⅜ in.	3.68	0.88	410	1020	1640	1940	2260	1450	1.09	160	510	740	980	1500	780
0 to ¾ in.	4.40	0.77	440	1060	1440	1890	2340	1430	0.97	200	580	960	1350	1490	920
Average	......	......	310	770	1180	1520	2120	1180	......	120	340	640	930	1300	670

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[1] Fineness modulus of aggregate; see Table III.

[2] Table V gives the *concentration* of tannic acid in terms of the weight of mixing water.

[a] Values interpolated on account of disintegration of some of the specimens.

headings. It should be understood, however, that all of these topics were studied in the same tests; consequently there is of necessity some overlapping in the discussion.

Effect of Quantity of Mixing Water.—The effect of water is mentioned first, due to the fundamental influence of this factor on the strength and other properties of the concrete. The

TABLE VI.—EFFECT OF TANNIC ACID ON THE STRENGTH OF CONCRETE.

Same data as in Tables IV and V, expressed as percentage of strength of concrete made from clean aggregate.

Size of Aggregate.	Tannic Acid.		Per Cent of Strength of Concrete with Clean Aggregates.						Tannic Acid.		Per Cent of Strength of Concrete with Clean Aggregates.					
	(1)[a]	(2)[b]	7 d.	28 d.	3 mo.	1 yr.	2 yr.	Average.	(1)[a]	(2)[b]	7 d.	28 d.	3 mo.	1 yr.	2 yr.	Average.
			Mix, 1 : 2 by Volume.								Mix, 1 : 3 by Volume.					
0 to No. 28......	0.05	0.21	100	94	110	103	96	101	0.05	0.24	95	103	88	114	89	98
0 to No. 14......	....	0.23	102	99	126	136	98	112	....	0.27	82	82	90	94	89	87
0 to No. 8......	....	0.25	88	90	98	92	94	92	....	0.30	83	81	86	94	93	87
0 to No. 4......	....	0.27	86	92	96	85	91	90	....	0.32	87	89	79	88	91	87
0 to $\frac{3}{8}$ in........	....	0.30	80	71	79	84	96	82	....	0.36	71	78	71	85	85	78
0 to $\frac{3}{4}$ in........	....	0.34	78	71	79	84	92	81	....	0.42	73	71	76	72	79	74
Average.....	....	0.27	89	86	98	97	94	93	....	0.32	82	84	82	91	88	85
0 to No. 28......	0.10	0.42	84	86	99	91	95	91	0.10	0.49	74	82	64	104	78	80
0 to No. 14......	....	0.46	80	81	118	110	95	97	....	0.53	75	81	79	85	77	79
0 to No. 8......	....	0.50	73	83	89	87	103	87	....	0.59	71	77	73	71	85	75
0 to No. 4......	....	0.54	68	65	88	57	83	72	....	0.64	52	57	62	72	68	62
0 to $\frac{3}{8}$ in........	....	0.60	74	73	79	77	95	80	....	0.72	57	66	64	71	75	67
0 to $\frac{3}{4}$ in........	....	0.68	65	72	79	85	98	80	....	0.84	56	60	66	61	74	63
Average.....	....	0.53	74	77	92	84	95	84	....	0.64	64	70	68	77	76	71
0 to No. 28......	0.20	0.84	68	72	87	82	94	81	0.20	0.98	56	67	56	84	65	66
0 to No. 14......	....	0.92	74	68	87	103	73	81	....	1.06	55	66	68	74	70	67
0 to No. 8......	....	1.00	71	71	74	83	96	79	....	1.18	47	59	57	61	65	58
0 to No. 4......	....	1.08	62	61	76	72	88	72	....	1.28	46	54	52	62	68	56
0 to $\frac{3}{8}$ in........	....	1.20	66	65	57	69	68	67	....	1.44	42	54	51	54	67	54
0 to $\frac{3}{4}$ in........	....	1.38	59	64	64	75	84	69	....	1.68	48	44	46	53	60	50
Average.....	....	1.07	67	67	76	81	84	75	....	1.27	49	57	55	65	66	58
0 to No. 28......	0.40	1.66	51	63	62	87	74	67	0.40	1.96	15	44	32	62	53	41
0 to No. 14......	....	1.84	59	55	66	84	68	66	....	2.12	25	44	33	46	46	39
0 to No. 8......	....	2.00	48	56	59	68	82	63	....	2.36	25	41	34	40	49	38
0 to No. 4......	....	2.16	57	52	66	62	66	61	....	2.56	42	50	41	51	59	49
0 to $\frac{3}{8}$ in........	....	2.40	62	55	53	63	68	60	....	2.88	30	39	40	54	59	44
0 to $\frac{3}{4}$ in........	....	2.76	49	54	50	60	64	55	....	3.36	31	39	41	45	51	41
Average.....	....	2.14	54	56	59	71	70	62	....	2.54	28	43	37	50	53	42

[a] Tannic acid, per cent of weight of aggregate.
[b] Tannic acid, per cent of weight of mixing water (concentration).

quantity of water used is expressed in terms of the "water-ratio" which is obtained by dividing the volume of water by the (loose) volume of the cement in the batch. Cement is considered as weighing 94 lb. per cu. ft. A rich mix will have a lower "water-ratio" than a lean one if the same aggregate is used and the concrete is mixed to a uniform plasticity. The

TABLE VI.—EFFECT OF TANNIC ACID ON THE STRENGTH OF CONCRETE.—*Continued.*

Size of Aggregate.	Tannic Acid.		Per Cent of Strength of Concrete with Clean Aggregates.						Tannic Acid.		Per Cent of Strength of Concrete with Clean Aggregates.					
	(1)[a]	(2)[b]	7 d.	28 d.	3 mo.	1 yr.	2 yr.	Average.	(1)[a]	(2)[b]	7 d.	28 d.	3 mo.	1 yr.	2 yr.	Average.
	Mix, 1 : 4 by Volume.								Mix, 1 : 5 by Volume.							
0 to No. 28	0.05	0.28	103	96	92	111	91	99	0.05	0.29	78	96	98	72	88	86
0 to No. 14	....	0.31	78	87	95	82	97	88	....	0.32	83	82	80	92	98	87
0 to No. 8	....	0.35	102	89	99	93	92	95	....	0.36	77	80	77	94	86	83
0 to No. 4	....	0.39	76	93	86	85	87	85	....	0.39	78	77	84	88	90	83
0 to $\frac{3}{8}$ in.	....	0.44	66	77	66	87	78	75	....	0.44	61	79	74	89	79	76
0 to $\frac{3}{4}$ in.	....	0.53	72	70	78	89	77	77	....	0.53	62	68	72	71	76	70
Average	....	0.38	83	85	86	91	87	86	....	0.39	73	80	81	84	86	81
0 to No. 28	0.10	0.57	47	84	63	87	70	70	0.10	0.58	57	80	77	78	90	76
0 to No. 14	....	0.62	83	80	80	79	86	82	....	0.64	69	75	73	78	94	78
0 to No. 8	....	0.70	70	75	80	93	97	83	....	0.72	62	56	78	74	81	70
0 to No. 4	....	0.78	61	72	73	82	71	72	....	0.78	53	67	61	67	57	61
0 to $\frac{3}{8}$ in.	....	0.88	67	62	62	93	63	69	....	0.88	54	69	68	76	74	68
0 to $\frac{3}{4}$ in.	....	1.06	70	53	72	79	54	66	....	1.05	56	58	58	57	52	56
Average	....	0.77	66	71	72	86	74	74	....	0.78	58	68	69	72	75	68
0 to No. 28	0.20	1.14	70	63	60	95	70	72	0.20	1.16	57	64	56	54	80	62
0 to No. 14	....	1.24	102	67	64	57	78	74	....	1.28	52	48	50	58	63	54
0 to No. 8	....	1.41	102	84	79	76	79	84	....	1.44	50	61	50	64	65	58
0 to No. 4	....	1.56	48	74	71	67	57	63	....	1.56	56	40	44	37	76	51
0 to $\frac{3}{8}$ in.	....	1.76	43	54	46	63	61	53	....	1.76	35	40	46	48	50	44
0 to $\frac{3}{4}$ in.	....	2.12	35	44	64	70	58	54	....	2.10	27	38	35	43	45	38
Average	....	1.54	67	61	64	71	67	67	....	1.55	46	48	47	51	63	51
0 to No. 28	0.40	2.28	86	71	50	60	63	66	0.40	2.32	31	38	95	44	72	56
0 to No. 14	....	2.48	56	49	52	43	75	55	....	2.56	31	36	40	65	73	49
0 to No. 8	....	2.82	30	48	54	56	68	51	....	2.88	24	28	38	54	62	41
0 to No. 4	....	3.12	54	85	64	59	73	67	....	3.12	22	33	31	41	49	35
0 to $\frac{3}{8}$ in.	....	3.52	49	61	51	57	55	55	....	3.52	28	42	39	42	45	39
0 to $\frac{3}{4}$ in.	....	4.24	41	48	42	50	47	46	....	4.20	22	33	33	39	34	32
Average	....	3.08	53	60	52	54	64	57	....	3.10	26	35	46	48	56	42

[a] Tannic acid, per cent of weight of aggregate.
[b] Tannic acid, per cent of weight of mixing water (concentration).

quantity of water used may be expressed in terms of gallons per sack of cement.

Figs. 1 to 3 show the relation between the water-ratio and the compressive strength at different ages for concrete without tannic acid and with 0.1 and 0.4 per cent tannic acid. Similar sets of curves may be drawn for 0.05 and 0.2 per cent tannic acid. The individual points are platted for 7-day and 1-year tests only. These figures show:

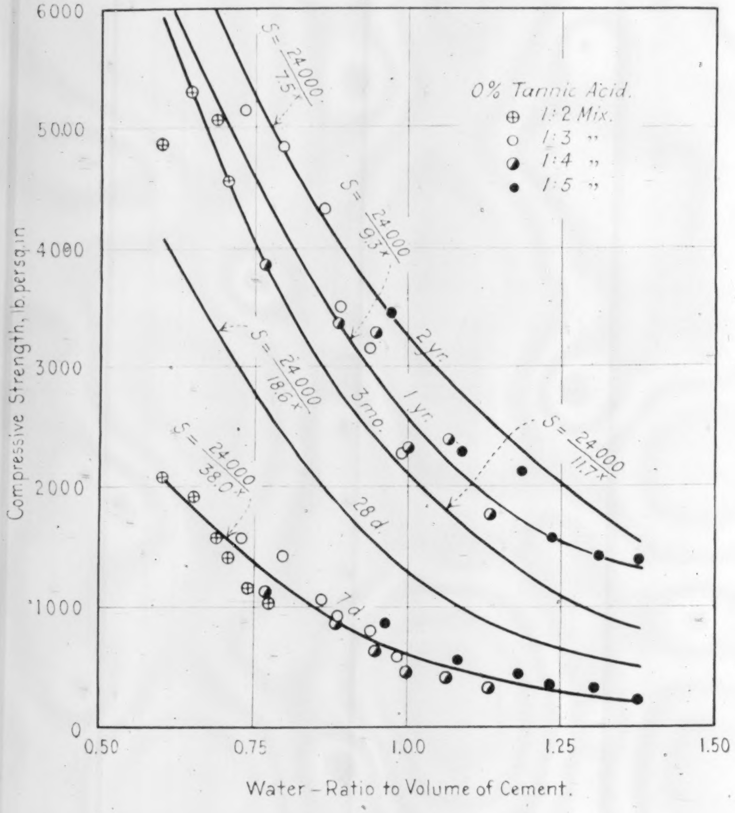

FIG. 1.—Water-ratio Strength Relation for Concrete without Tannic Acid.

Each value is the average of 4 tests made on different days.
Points are shown for 7-day and 1-year tests only.
Compare Figs. 2 and 3.

1. The age of the concrete and the presence of tannic acid change the strength of the concrete, but the same type of relation is preserved for all conditions.

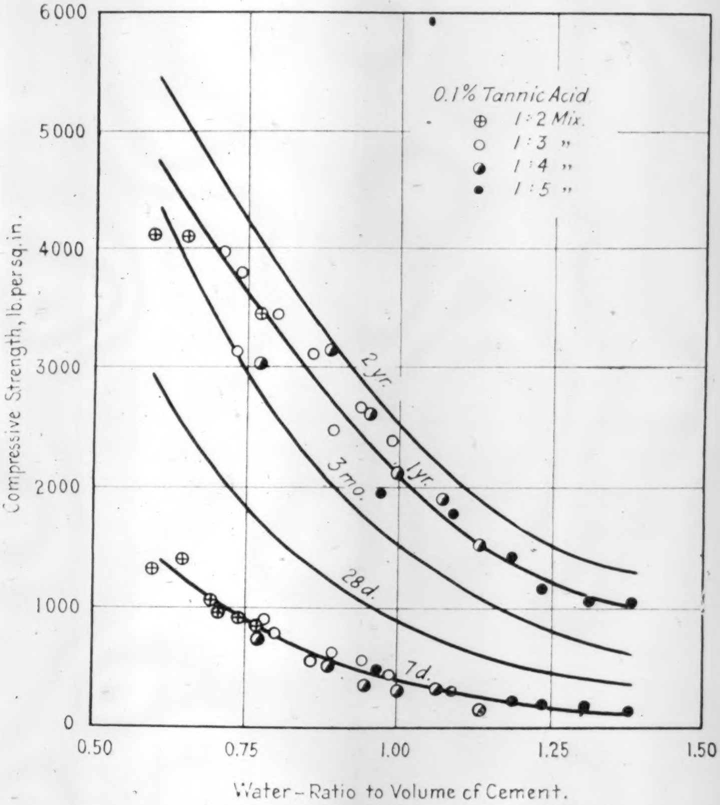

FIG. 2.—Water-ratio Strength Relation for Concrete with 0.10 per cent Tannic Acid.

Each value is the average of 4 tests made on different days.
Points are shown for 7-day and 1-year tests only.
Compare Figs. 1 and 3.

2. The strength of the concrete is rapidly reduced with the increase in water-ratio for all ages and all percentages of tannic acid.

3. A constant relation exists between strength of concrete and the water-ratio, regardless of mix or size and grading of aggregate.

4. The more tannic acid used, the lower the strength of the concrete for all mixes, ages and sizes of aggregate.

The tests in this series confirm the results of many other investigations carried out in this laboratory in showing that the water-ratio determines the strength of the concrete, so far as the quantity of cement and the size and grading of aggregate are concerned, and so long as the concrete is plastic and the aggregate is not graded too coarse for the quantity of cement used.

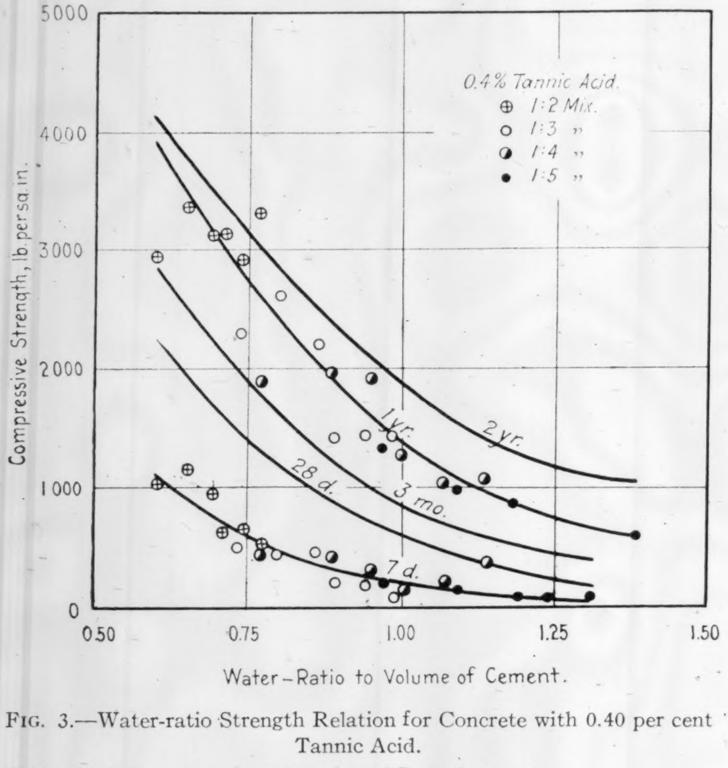

FIG. 3.—Water-ratio Strength Relation for Concrete with 0.40 per cent Tannic Acid.

Each value is the average of 4 tests made on different days.
Points are shown for 7-day and 1-year tests only.
Compare Figs. 1 and 2.

The water-ratio-strength curves for these tests are of the form:

$$S = \frac{A}{B^x} \quad \text{(1)}$$

where S = compressive strength of concrete and x = water-ratio of mix (an exponent). A and B are constants which depend on the quality of the cement and the conditions of the test.

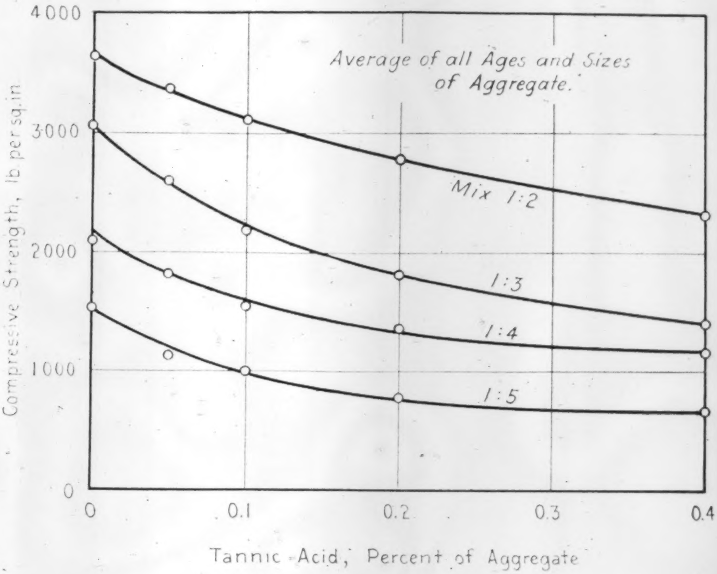

FIG. 4.—Effect of Tannic Acid on the Strength of Concrete of Different Mixtures.

Compare Fig. 5.
In general, the values are the average of 120 tests from 6 sizes of aggregate and 5 ages.

The 28-day tests without tannic acid (Fig. 1) conform to he relation expressed by the equation

$$S = \frac{24000}{18.6^x} \quad \text{(2)}$$

The corresponding equations for other ages are given in Fig. 1. Equations of similar form may be derived for other percentages of tannic acid. The relation between strength and water-ratio for specimens with 0.10 per cent and 0.40 per cent of tannic acid is platted in Figs. 2 and 3.

Certain other series of concrete tests made in this laboratory conform more closely to a curve of somewhat different type, which, however, gives essentially the same values for the usual range of concrete mixtures. The type of the curve is of minor importance; the significant feature is that the water-ratio determines the strength of the concrete for given materials.

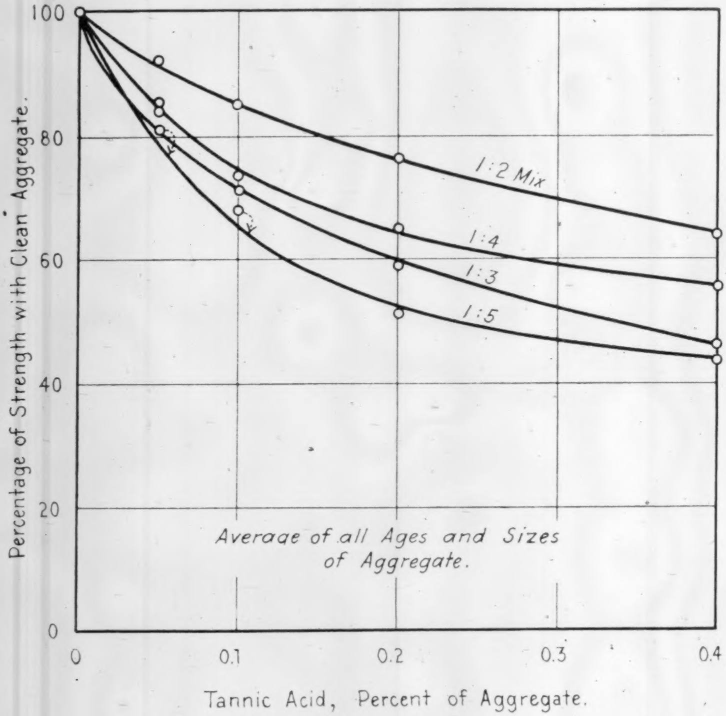

FIG. 5.—Effect of Tannic Acid on the Strength of Concrete of Different Mixtures.

Same data as in Fig. 4, except that values are expressed as percentages of the strength of concrete made from clean aggregates.

Fig. 6 shows the same data in a different form.

Effect of Quantity of Tannic Acid.—The effect of quantity of tannic acid is shown in a number of the figures. In Fig. 4

the effect of tannic acid is shown for each mix. All ages and sizes of aggregates have been averaged. It will be seen by reference to Fig. 9 that the age of the concrete has only a slight effect. Each point in Fig. 4 represents 120 tests from 5 ages and 6 sizes of aggregate. In Fig. 5 the same tests are platted using the average strength without tannic acid as 100 per cent.

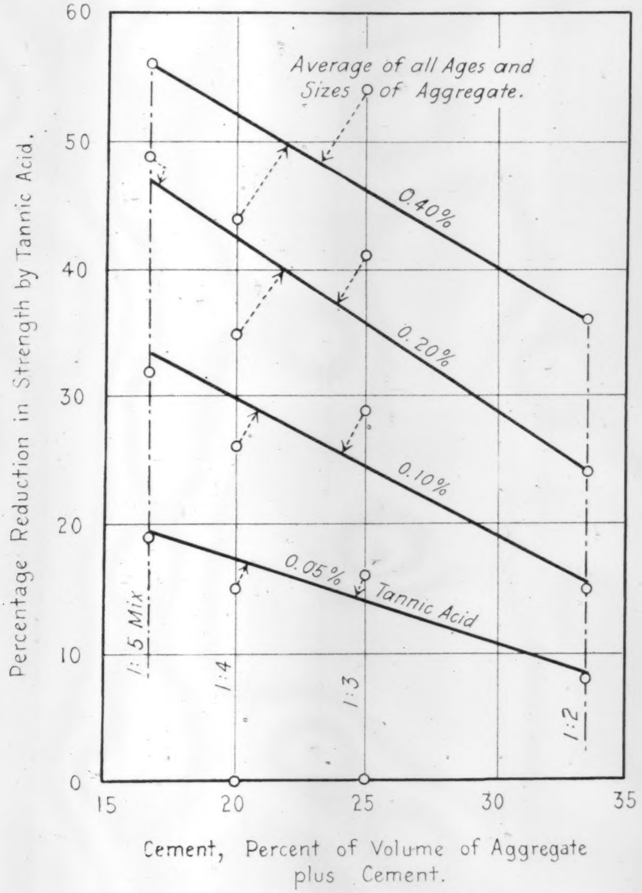

FIG. 6.—Reduction in Strength of Concrete of Different Mixtures by Tannic Acid.

In general, the values are the average of 120 tests from 6 sizes of aggregate and 5 ages. Compare Fig. 5.

It will be noted that the curves are similar for all mixes, although the reduction in strength due to the presence of tannic acid is considerably greater for the lean than for the rich mixtures. Very small percentages of tannic acid as a surface coating on the aggregate have the effect of materially reducing the strength of concrete for all mixes covered by these tests. Less than 0.1 per cent in terms of the weight of the aggregate may reduce the

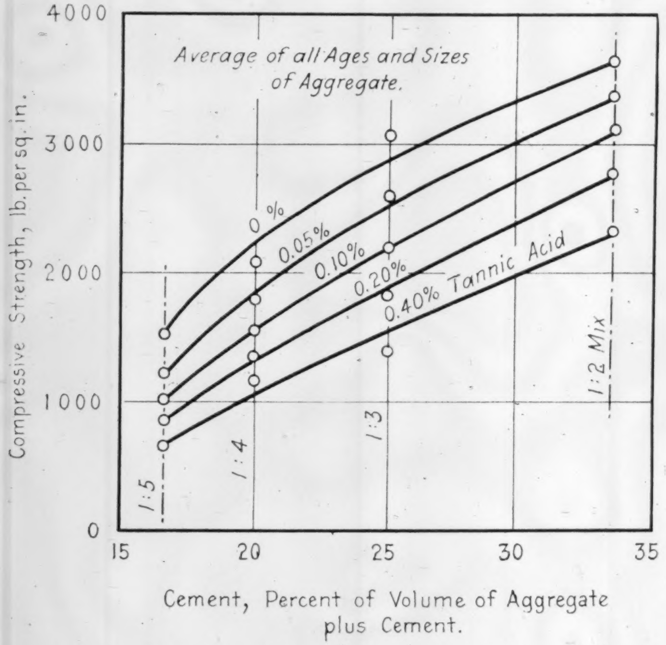

FIG. 7.—Effect of Quantity of Cement on the Strength of Concrete.
In general, the values are the average of 120 tests from 6 sizes of aggregate and 5 ages.

strength to one-half its original value. For the 1:4 mix the strength is reduced about 15 per cent for 0.05 per cent tannic acid; about 33 per cent for 0.10 per cent tannic acid; and nearly 50 per cent for 0.40 per cent tannic acid.

These tests confirm the results of earlier experiments made in this laboratory so far as the quantitative effect of organic impurities is concerned.

Effect of Quantity of Cement.—These tests give information on the effect of quantity of cement on the strength of concrete with and without tannic acid. Figs. 4 and 5 discussed above show the effect of the quantity of cement as expressed by the mix. In Fig. 7 the results of the tests are platted with reference to the percentage of cement in the batch. Fig. 6 shows the average *reduction* in strength for different percentages of tannic acid. The quantity of cement is expressed as a percentage of the volume of the cement plus aggregate. A 1:4 mix contains 20 per cent cement on this basis; a neat cement mix would be 100 per cent.

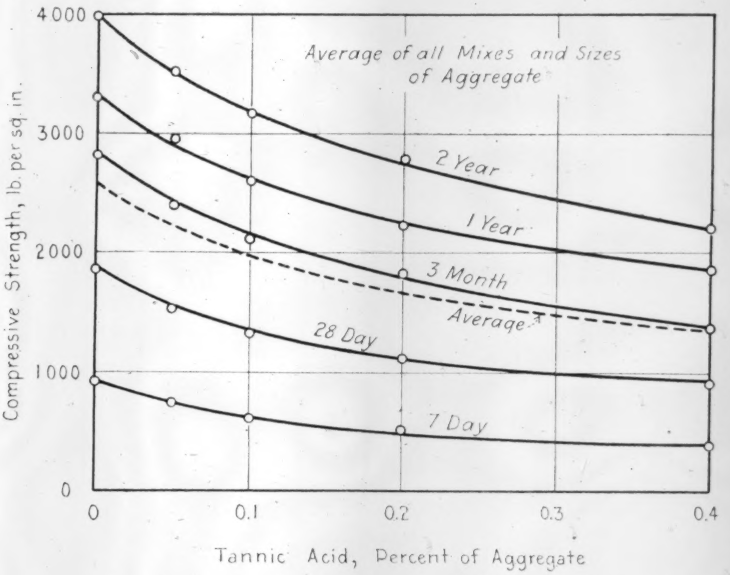

FIG. 8.—Effect of Tannic Acid on the Strength of Concrete at Different Ages.
Compare Fig. 9.
In general, the values are the average of 96 tests from 4 mixes and 6 sizes of aggregate.

The rich mixtures are less affected by tannic acid than the lean ones. A 1:5 mix was reduced in strength 33 per cent by 0.10 per cent tannic acid; the reduction for 1:4, 1:3 and 1:2 mixes are 30, 25 and 18 per cent, respectively, for the same quantity of tannic acid. It should be noted that these are average values of all ages and sizes of aggregate. There are somewhat less important differences in strength due to the age of the concrete and the size of aggregate as shown in Figs. 9 and 10. As is indicated in Table V, some of the 1:5 mixes with finer sands disintegrated before the time of test. It was impossible to remove the 1:7 mixes from the molds without breakage.

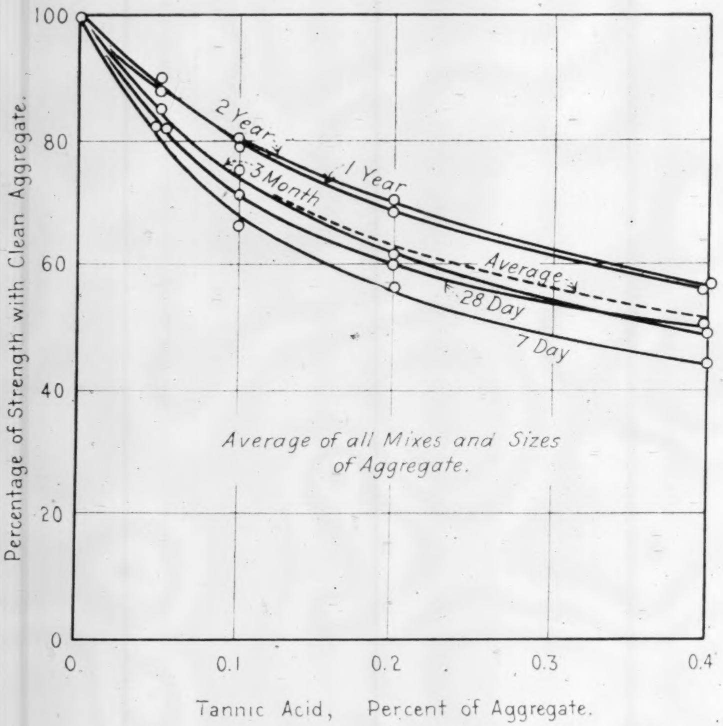

FIG. 9.—Effect of Tannic Acid on the Strength of Concrete.

Same data as in Fig. 8, except that values are expressed as percentages of the strength of concrete made from clean aggregates.

Fig. 15 shows the same data in a different form.

Effect of Size of Aggregate.—The size and grading of the aggregate is conveniently measured by its fineness modulus. In Fig. 10 the relation of strength to tannic acid is shown for each size of aggregate. In this diagram, mixes ranging from 1:5 to 1:2, and ages at test ranging from 7 days to 2 years have been averaged. The reduction in strength for each percentage of tannic acid is shown in Fig. 11. The finer sizes of sand are less affected than the coarser sizes; the coarser aggregates suffer about 20 per cent greater reduction in strength than the finest sand.

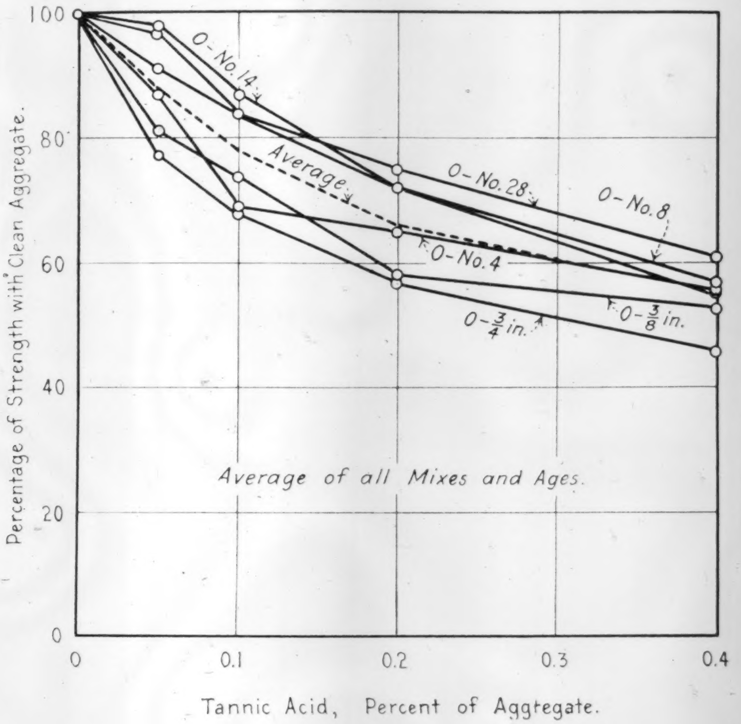

FIG. 10.—Effect of Tannic Acid on the Strength of Concrete Made of Aggregates of Different Gradings.

Values are expressed as percentages of the strength of concrete made from clean aggregates.

In general, each value is the average of 80 tests from 4 mixes and 5 ages.

Fig. 11 shows the same data in a different form.

Fig. 12 shows the relation between the fineness modulus and the compressive strength of the concrete; a separate curve is drawn for each percentage of tannic acid. For the aggregate gradings used, the strength of the concrete increased with the fineness modulus of the aggregate for all mixes and percentages of tannic acid. These curves bear out the results of other tests made in this laboratory with reference to the use of the fineness modulus as a measure of the size and grading of aggregates. It was pointed out in one of our earlier reports that the fineness modulus may be considered as a measure of the quantity of water required to produce a concrete of uniform workability. Since the water content dictates the strength of concrete, the fineness modulus gives a satisfactory method of dealing with strength also. This function has been used as a basis for the "design" of concrete mixtures.[1]

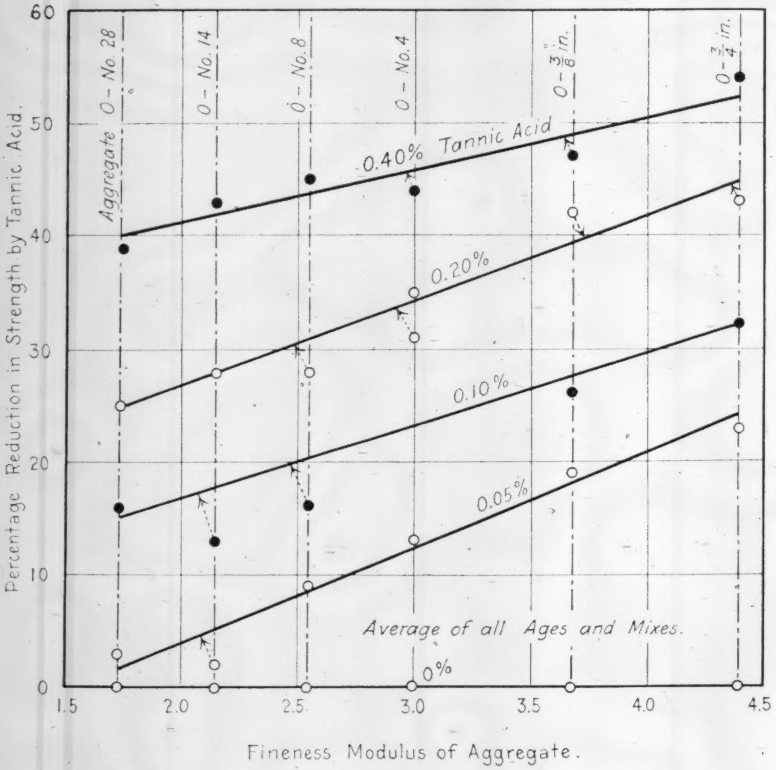

FIG. 11.—Reduction in Strength of Concrete by Tannic Acid.

In general, the values are the average of 80 tests from 4 mixes and 5 ages. Compare Fig. 10.

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[1] See *Bulletin 1* referred to previously.

General Discussion of Effect of Tannic Acid on the Strength of Concrete.—Fig. 16 shows the relation between the concentration of an aqueous solution of tannic acid and the strength of the concrete expressed as a percentage of the strength of concrete containing no tannic acid. Only the 28-day tests are platted. Similar curves may be drawn for other ages from the values given in Tables VI.

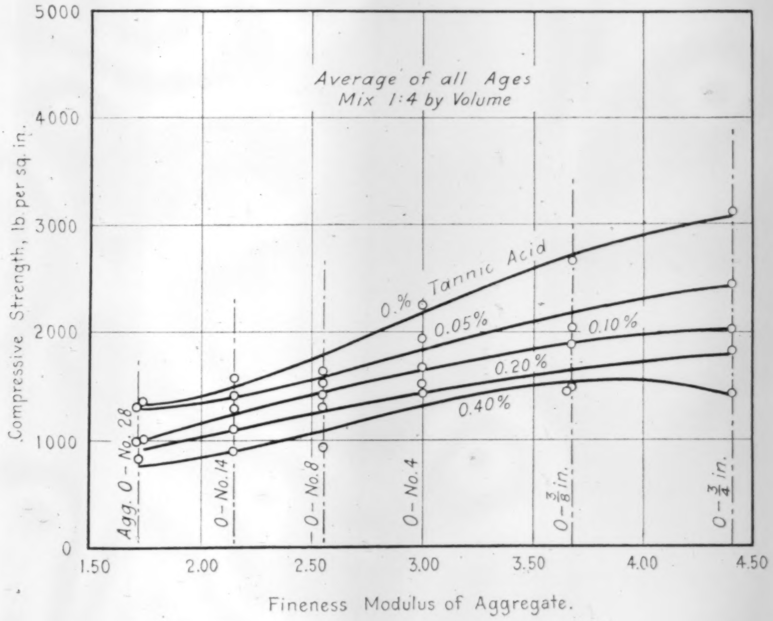

FIG. 12.—Effect of Size of Aggregate on the Strength of Concrete.

Mix 1 : 4 by volume.
In general, the values are the average of 20 tests from 5 ages.
Similar curves may be drawn for 1 : 2, 1 : 3 and 1 : 5 mixes.

The following equation represents the average values in Fig. 16, for the range of tests herein reported:

$$P = \frac{70}{2.1^t} + 30$$

where P = per cent of strength of concrete with clean aggregates
t = tannic acid (per cent of weight of mixing water, an exponent).

It was pointed out above that there is an intimate relation between the strength of the concrete and the water-ratio. The water-ratio may be varied by any one (or combinations) of the following methods:

1. Changing the mix.
2. Changing the grading of the aggregate.
3. Changing the consistency of the concrete.

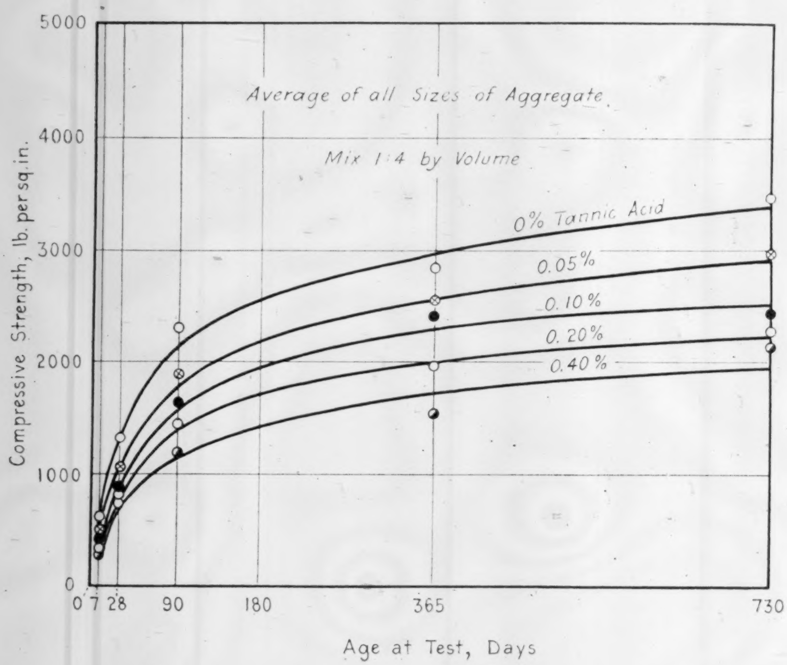

FIG. 13.—Effect of Age on the Strength of Concrete.

Mix 1 : 4 by volume.
In general, the values are the average of 24 tests from 6 sizes of aggregate.
Similar curves may be drawn for the other mixes from data in Tables IV and V.
Compare Fig. 14.

In view of the well-defined water-ratio-strength relation let us see if the relation brought out by Fig. 16 is in agreement with the information in Tables IV, V and VI and Figs. 5, 6, 10 and 11.

Consider for example the 0 to $\frac{3}{4}$-in. aggregate coated with 0.40 per cent tannic acid. Assume this aggregate to be mixed in one-bag batches of concrete, using 1:2 and 1:5 mixes respectively. It is obvious that the quantity of tannic acid in the batch of 1:5 concrete is $2\frac{1}{2}$ times that in the 1:2 concrete. Reference to Tables IV and V shows that the increase in water content in the 1:5 concrete over the 1:2 is only 61 per cent; therefore, the concentration of the tannic acid solution is less in the richer mixtures, and accordingly the reduction in strength of the concrete is less.

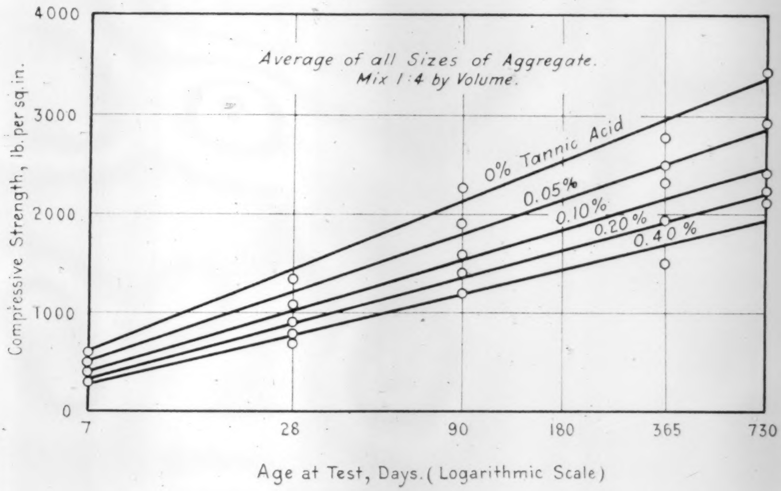

FIG. 14.—Effect of Age on the Strength of Concrete.

Mix 1 : 4 by volume.
Same data as in Fig. 13 with age platted to logarithmic scale.
In general, the values are the average of 24 tests from 6 sizes of aggregate.
Similar curves may be drawn for the other mixes from data in Tables IV and V.

Figs. 10 and 11 and Table VI show that other factors being constant, concrete made from the finer aggregate is less affected than that made from the coarser aggregates. Reference to Tables IV and V will show that concrete made from the finer aggregate contains more water and therefore, for a given mix, given consistency, and given percentage of tannic acid (in terms of the aggregate), the concentration of the tannic acid solution will be less and consequently the reduction in strength of the concrete less for the finer aggregate.

The Effect of Consistency of Concrete.—In these series of tests the consistency of the concrete was not varied. However, the general relation brought out by Fig. 16 indicates that the wetter consistencies would be less affected than the drier ones, since the concentration of the tannic acid will become less as the consistency of the concrete is increased.

Age of Concrete.—The effect of age on the strength of concrete is shown in Figs. 13 to 15. The strength of the concrete increased with the age according to a definite law for all mixes, both with and without tannic acid. The curves in Fig. 14 (which are the same as Fig. 13, except for the age scale) show that there is a linear relation between the strength of concrete and the logarithm of its age up to 2 years, so long as the concrete is not allowed to dry out. Average strengths for 1:4 concrete without tannic acid (Figs. 13 and 14) were about as follows:

7 days	600 lb. per sq. in.
28 "	1400 " " " "
3 months	2100 " " " "
1 year	3000 " " " "
2 years	3400 " " " "

It should be borne in mind that the average aggregate was quite fine, consequently the above strengths are much lower than would have been secured with the usual concrete aggregates. Diagrams similar to Figs. 13 and 14 may be drawn for the other

TABLE VII.—WEIGHT OF CONCRETE.

Weights determined immediately after removal from form.
Each value is based on the weights of twenty 3 by 6-in. cylinders.
The presence of tannic acid had no appreciable influence on the weight of the concrete.

Size of Aggregate.	Weight of Concrete, lb. per cu. ft.			
	Mix 1 : 2	Mix 1 : 3	Mix 1 : 4	Mix 1 : 5
0 to No. 28	134	133	129	127
0 to No. 14	137	135	132	131
0 to No. 8	139	137	135	133
0 to No. 4	143	141	140	139
0 to $\frac{3}{8}$ in	146	145	143	143
0 to $\frac{3}{4}$ in	148	149	147	147

mixes from values in Tables IV and V. Concrete which has thoroughly dried out shows little or no further increase in strength, so long as it remains dry. The relation between age and strength of concrete shown by these tests have been brought out by many other groups of tests carried out in this and other laboratories.[1]

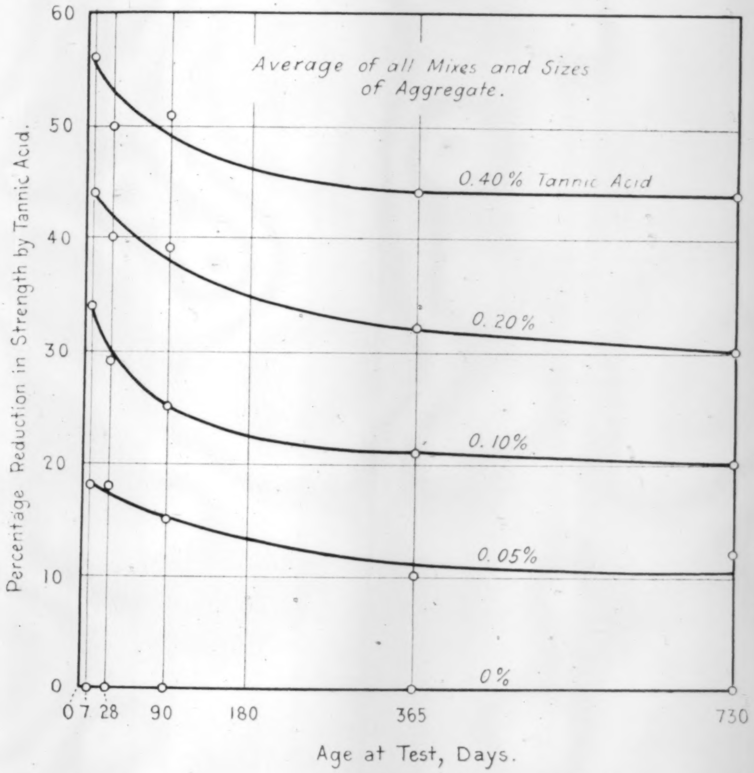

FIG. 15.—Reduction in Strength of Concrete of Different Ages by Tannic Acid.

In general, the values are the average of 120 tests from 6 sizes of aggregate and 5 mixes. Compare Fig. 9.

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[1] See Duff A. Abrams, "Effect of Age on the Strength of Concrete," *Proceedings*, Am. Soc. Test. Mats., Vol. XVIII, Part II, (1918), and H. F. Gonnerman, "Some Tests on Age and Strength of Concrete," *Proceedings*, American Concrete Institute (1918).

The values in Figs. 9 and 15 bring out the relative effect of the age of the concrete as it is influenced by the presence of tannic acid. In these figures all mixes and sizes of aggregate have been averaged. At 7 days the strength is reduced by about 33 per cent by 0.10 per cent tannic acid; for the same condition the strength is reduced about 30 per cent at 28 days and about 20 per cent at 1 and 2 years. For all mixes and sizes of aggregate, the strength is reduced to a greater extent at 7 and 28 days than at 1 and 2 years.

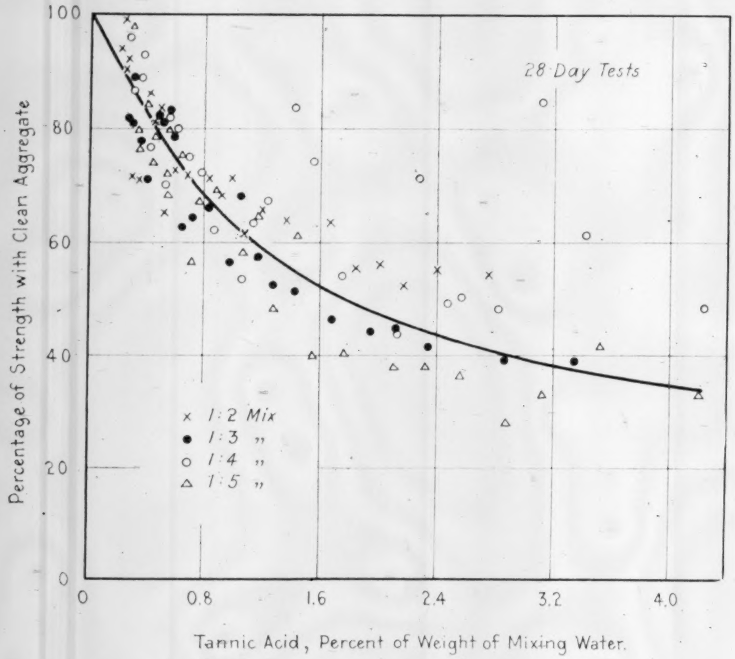

FIG. 16.—Effect of Tannic Acid on the Strength of Concrete.

The values are the average of 4 tests made on different days.
Similar curves may be drawn from data in Table VI for 7-day, 3-month, 1 and 2-year tests.

Surface Loam.—The tests and discussion show the importance of avoiding the use of sands containing organic impurities. Surface loam is a common source of organic material. Contrary to the conclusions based on numerous published tests, surface loam *always decreases* the strength of a *properly proportioned* concrete due to two distinct causes:

1. Presence of organic materials.
2. Additional water required to produce a concrete of a given plasticity.

A concrete in which the aggregate is too coarse for highest strength may be slightly improved by the addition of loam or other finely divided material. This means simply that the increase in strength due to a better grading of aggregates more than counterbalances the ill effects of the admixture.

Care should always be taken to remove the overburden of soil in sand and gravel pits. Washing when on a comprehensive scale is generally effective in removing loam. A superficial examination may not reveal the presence of organic impurities in sands. The colorimetric test described below is the only safe guide now known.

TEST FOR ORGANIC IMPURITIES IN SANDS.

Untried sands should always be tested for organic impurities before they are used in concrete. The "colorimetric" test has been found serviceable for this purpose. The test may be made in the field with little difficulty. The field test consists of shaking the sand thoroughly in a dilute solution of sodium hydroxide ($NaOH$) and observing the resultant color after the mixture has been allowed to stand for a few hours. Fill a 12-oz. graduated prescription bottle to the $4\frac{1}{2}$-oz. mark with the sand to be tested. Add a 3-per-cent solution of sodium hydroxide until the volume of the sand and solution, after shaking, amounts to 7 oz. Shake thoroughly and let stand for 24 hours. Observe the color of the clear liquid above the sand. A good idea of the quality of the sand can be formed earlier than 24 hours, although this period is believed to give best results. If the solution resulting from this treatment is colorless, or has a light yellowish color, the sand may be considered satisfactory in so far as organic impurities are concerned. On the other hand, if a dark-colored solution is produced, the sand should not be used in high-grade concrete, or used only after mortar-strength tests have shown it to be satisfactory for the purpose.

The 1919 report of Committee C-9 on Concrete and Concrete Aggregates of the American Society for Testing Materials contains a description of the above-mentioned test under the title "Abrams-Harder Field Test for Organic Impurities in Sands." A colored plate which accompanies that report will be of assistance in interpreting the results of the colorimetric test.[1]

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XIX, Part I, p. 321 (1919).

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APPENDIX III.

REPORT OF SUB-COMMITTEE VI ON WEIGHT, VOIDS, DENSITY, SPECIFIC GRAVITY AND CONSISTENCY.

The investigations on Unit Weight of Aggregates conducted by Sub-Committee VI have extended over a long period of time due to interruptions of war work and other causes.

The object of the investigation was to determine the method and apparatus by which the most satisfactory results may be obtained in the determination of the unit weight of aggregates by different operators under different conditions.

The variables to be standardized are as follows:

1. The size and shape of the measure;
2. The method of filling the measure;
3. The amount of moisture in the aggregate.

The sub-committee selected nine methods and drew up a complete description of the apparatus and methods to be used in making the determinations of unit weight and computed and tabulated all results reported.

The following laboratories cooperated in the investigation:

The New England Bureau of Tests.
Westinghouse, Church, Kerr and Co.
The Pittsburgh Testing Laboratory.
The N. Y. Public Service Commission Laboratory.
The Columbia University.
The Lehigh University.
The Bureau of Public Roads of the U. S. Department of Agriculture.

The aggregates used were of two grades, a coarse and a fine sand. The coarse sand showed not over 15 per cent passing a 50-mesh sieve. The fine sand showed not over 20 per cent retained on a 30-mesh sieve. Both of these sands were used in a dry and in a moist condition. The dry sand was dried at room temperature until it flowed freely through the fingers, and did not contain more than 1 per cent of moisture. The damp sand had enough water added to it to bring the moisture to about 5 per cent in the case of the fine sand and about 3 per cent in the case of the coarse sand.

The sand was tested each day for the percentage of moisture before the tests were started for that day. Care was taken that these percentages were approximately maintained throughout the tests, water being added from time to time as the tests proceeded in order to take the place of that lost through evaporation.

Four sizes of measures were used, having capacities respectively of 100 cc., 1000 cc., $\frac{1}{4}$ cu. ft. and 1 cu. ft. The 100-cc. measure was cylindrical and about $1\frac{1}{4}$ in. in diameter by $5\frac{1}{2}$ in. high. The 1000-cc. measure was cylindrical with a diameter of $3\frac{1}{2}$ in. and height of $6\frac{1}{2}$ in. Two $\frac{1}{4}$-cu. ft. measures were made, one cylindrical and one cubical. In the case of the $\frac{1}{4}$-cu. ft. cylindrical measure the diameter was 8 in. and the height $8\frac{1}{2}$ in. The $\frac{1}{4}$-cu. ft. cubical measure measured $7\frac{9}{16}$ in. each way. Two 1-cu. ft. measures were also made, one cylindrical and one cubical. In the case of the former the diameter was 13 in. and the height 13 in., while the latter was 12 in. each way.

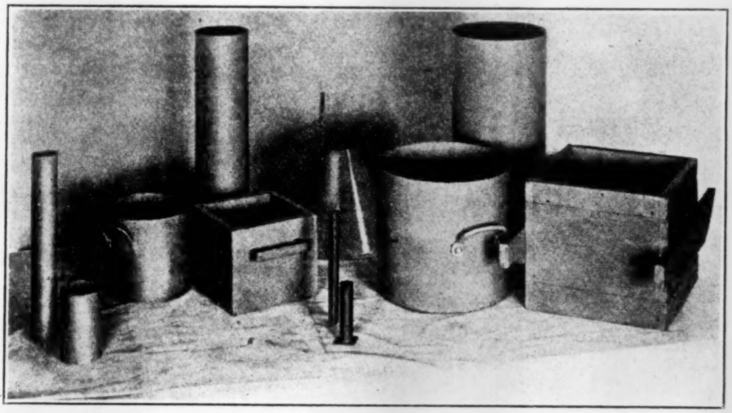


FIG. 1.—Showing Measures and Filling Tubes.

The 100-cc. and 1000-cc. cylindrical measures were made of galvanized sheet iron with galvanized iron bottom; the $\frac{1}{4}$-cu. ft. and 1-cu. ft. cylindrical measures were made of iron pipe cut to proper lengths with metal bottoms. The $\frac{1}{4}$-cu. ft. and 1-cu. ft.

cubical measures were made up either of substantial sheet metal or well waterproofed wood.

Later, in a second investigation, a fifth size of measure was used. This was a truncated cone made of No. 16-gage galvanized iron with the base soldered on and the top open. The diameter of the base was 10 in. and the height 10 in., and the diameter of the opening in the top 3 in. Its capacity was 0.2066 cu. ft.

The seven measures were all accurately weighed, and the five metal measures had their cubic capacity determined by weighing the quantity of water required to fill them level full. The two wooden measures had their cubic capacity determined by carefully measuring along each of their twelve edges, and computing their volume.

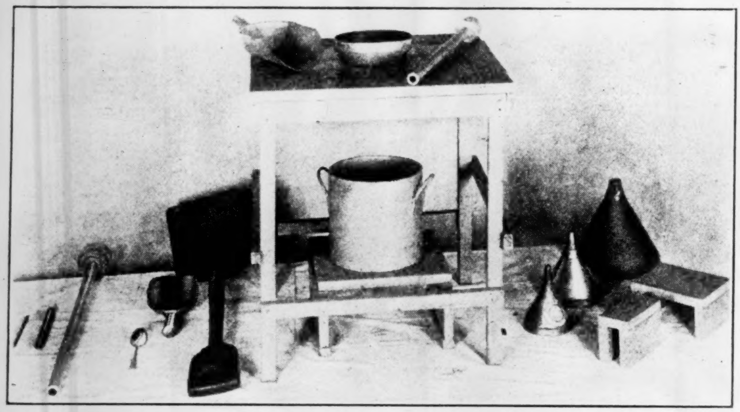


FIG. 2.—Additional Apparatus Used in Filling Measures.

For use with these measures there were four metal tubes, open at both ends, having capacities respectively of 110 cc., 1100 cc., $\frac{3}{10}$ cu. ft. and $1\frac{1}{10}$ cu. ft.

These tubes were made to the following approximate dimensions:

110-cc. tube	1 in. in diameter	by 11 in. long
1100-cc. tube.	$2\frac{1}{4}$ in. in "	by $17\frac{1}{2}$ in. "
$\frac{3}{10}$-cu. ft. tube	6 in. in "	by $16\frac{3}{4}$ in. "
$1\frac{1}{10}$-cu. ft. tube	10 in. in "	by 24 in. "

There were also four tampers, for the four capacities of measures, of the following description:

For the 100-cc. measure, a $\frac{1}{4}$-in. round iron rod 8 in. long.
For the 1000-cc. measure, a $\frac{7}{8}$-in. round iron rod 12 in. long.
For the $\frac{1}{4}$-cu. ft. measure, a tamper having a circular flat head 2 in. in diameter with a handle from 18 in. to 24 in. long, the whole tamper weighing 3 lb.
For the 1-cu. ft. measure, a tamper having a circular flat head 3 in. in diameter with a handle from 2 to 3 ft. long, the whole tamper weighing 5 lb.

Four funnels were provided, having openings respectively $\frac{3}{8}$, $\frac{5}{8}$, $\frac{7}{8}$, and $1\frac{1}{4}$ in. in diameter, for filling the measures. Each funnel was provided with a rigid support for holding it in a fixed position above the measure it was used to fill.

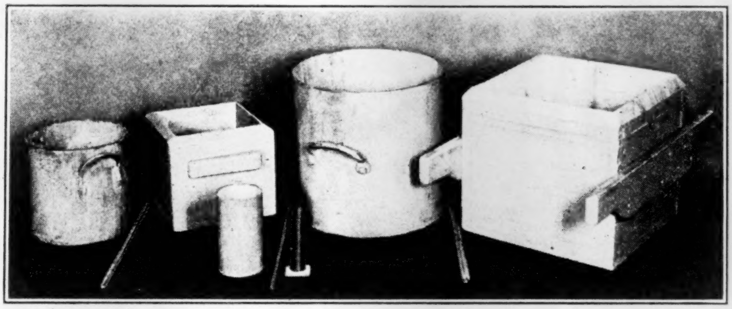


FIG. 3.—Measures and Rods Used in the Rod Method.

There were also three wooden stands of various heights used in conjunction with the support for the funnels. One of these was placed under the measure according to its height and insured that the distance from the bottom of the funnel to the top of the measure was as called for in Method of Filling F.

For filling the measures, the following apparatus was also used:

For the 100-cc. measure, a large spoon or tablespoon.
For the 1000-cc. measure and $\frac{1}{4}$-cu. ft. measure, metal scoops.
For the 1-cu. ft. measure, a shovel.
One or more metal straight edges for striking off tops of measures when full.

All of this apparatus except the straight edges is shown in Figs. 1 and 2.

In Fig. 2 is illustrated the table for supporting the funnel when filling the measure, showing the $\frac{1}{4}$-cu. ft. round measure in place on the stand provided for it, with the scoop, tamper and funnel used in filling this measure laid upon the table.

In Fig. 3 is shown the group of measures used in the Rod Method and also the rods used with these measures. There were three of these which were respectively $\frac{1}{4}$, $\frac{1}{2}$ and $\frac{3}{4}$ in. in diameter by 18 in. long. The $\frac{1}{4}$-in. rod was used with the 100-cc. and 1000-cc. measures. The $\frac{1}{2}$-in. rod was used with the $\frac{1}{4}$-cu. ft. round and $\frac{1}{4}$-cu. ft. square measures, while the $\frac{3}{4}$-in. rod was used with the 1-cu. ft. round and 1-cu. ft. square measures.

The nine different methods of filling the measures described are designated as A, B, C, D, E, F, G, H, and Cone Methods. The instructions given each laboratory were as follows:

Method A: Filled and Struck.—Place the measure on a firm level surface. Fill with the sand, using a spoon, scoop, or shovel, depending on the size of measures, taking several quantities of sand from different parts of the sample. Fill the measure to overflowing, and without jarring or moving it, strike off the surplus sand from the top with a straight edge. Place measure on scales and weigh.

Method B: Filled and Jarred.—Fill measure to overflowing by putting in several portions with spoon, scoop or shovel. Jar measures in the following manner: In the case of the 100-cc. and 1000-cc. cylinder, tip the measure about 10 degrees from the vertical and jar by lifting and dropping about one inch, 25 times, allowing the measure to strike on the outer edge at the bottom, and rotating the measure during the process, so the sand moves from one side to the other in the measure. In the case of the $\frac{1}{4}$-cu. ft. and 1-cu. ft. measures, jar by rocking from side to side 25 times, then fill to overflowing, strike off and weigh.

Method C: Jarred while Filling.—Fill measure one-sixth full, jar 15 times as described in Method B, add another sixth and jar again in a similar manner. Repeat until full. After last jarring fill to overflowing, strike off and weigh.

Method D: Tamped in Layers.—Fill measure one-sixth full and tamp 20 times with proper tamper, using short quick strokes. Add another one-sixth and repeat until full. Then fill to overflowing, strike off and weigh.

Method E: Filled and Tamped.—Fill measure with spoon or shovel and tamp 25 times with proper tamper, using strong strokes, fill to overflowing, strike off and weigh.

Method F: Filled Through Funnel.—Support funnel rigidly over the middle of the top of the measure with the bottom of the outlet at the following heights:

For 100-cc. measure	2 in.
For 1000-cc. "	3 "
For ¼-cu. ft. "	5 "
For 1-cu. ft. "	7½ "

This will allow the sand to pile up in a cone above the top of the measure without reaching to the bottom of the funnel. Fill the measure by placing sand in the funnel, always keeping a steady flow from the mouth of the funnel. Always have sand in the funnel, so that the flow will be uninterrupted till measure is full. In making the damp sand tests, a small wire constantly moved about in the mouth of the funnel will keep the sand flowing. Keep the wire in the neck of the funnel and continually moving while the measure is being filled. Fill measures to overflowing, strike off and weigh.

Method G: Inner Tube.—Stand the tube holding 10 per cent more than the measure upright in the center of the measure. Fill the tube with sand. Without moving or jarring the measure, slowly lift the tube at a speed of about 1 in. per second out of the measure, allowing the sand in the tube to flow from the bottom of the tube and fill the outer measure. Strike off the surplus sand from the top and weigh.

Method H: Rod Method.—Fill the measure one-third full, level off top surface with the fingers, tamp with pointed rod 25 times. Fill measure two-thirds full and tamp 25 times. Fill measure to overflowing, tamp 25 times. Strike off surplus aggregate, using rod as straight edge and weigh.

Cone Method.—Fill the measure with aggregate. Place a tuft of waste over the top opening to prevent spilling and rock violently back and forth on its base about 30 times. Refill when the sand has settled and repeat the rocking until there is no more settlement of the aggregate in the measure. Strike off and weigh.

The first seven of these methods were investigated in each of the seven cooperating laboratories, while the last two were tested in the laboratory of Westinghouse, Church, Keer and Co. by seven different operators.

The results obtained show an extremely wide variation in unit weight with the different methods used. To conserve space the detailed tables of individual weights are omitted and only summaries are presented.

Table I and Curves I*a* and I*b*.

This data and Curves I*a* show the average of the weight per cubic foot obtained by all laboratories by each method with each sand plotted to "pounds per cubic foot" and "size of measure." The four curves under each method are arranged in the order stated on the curve sheet.

Curves I*a* show graphically the data set forth in Table I. Many interesting features are shown by these curves but they are shown to better advantage in other curves which follow.

In all of these tables and curves it should be borne in mind that the cone method was used with one size of measure only and the results could therefore not be averaged in with measures of other sizes. The results of the cone method are therefore indicated separately on the diagram or as a note.

TABLE I.—AVERAGE WEIGHTS FOR ALL LABORATORIES.

Weight in pounds per cubic foot.

Measure.	Sand.		Method.								
			A	B	C	D	E	F	G	H	Cone
100 cc......	Coarse	Dry	100.0	106.3	109.6	109.3	104.8	101.4	97.4	106.5	....
		Wet	75.1	92.8	100.8	102.4	90.1	74.3	73.7	99.5	....
	Fine	Dry	89.7	97.6	100.9	99.9	96.5	90.4	89.9	98.3	....
		Wet	66.7	86.0	95.5	93.7	80.2	59.2	64.5	89.4	....
1000 cc.....	Coarse	Dry	100.1	106.2	109.9	109.3	105.3	98.2	99.4	107.5	....
		Wet	81.0	96.5	101.7	105.1	96.5	76.0	79.4	89.5	....
	Fine	Dry	91.4	97.9	102.3	101.6	96.8	89.6	90.4	100.3	....
		Wet	72.2	88.5	94.8	97.9	89.1	62.5	72.3	77.3	....
$\frac{1}{5}$ cu.ft.cone	Coarse	Dry	....	....	....	....	....	....	....	....	115.3
		Wet	....	....	....	....	....	....	....	....	105.7
	Fine	Dry	....	....	....	....	....	....	....	....	117.2
		Wet	....	....	....	....	....	....	....	....	108.2
$\frac{1}{4}$ cu. ft. rd.	Coarse	Dry	100.4	107.3	111.0	110.9	106.2	96.3	99.3	108.0	....
		Wet	88.2	99.7	103.8	109.2	101.3	81.5	86.9	92.6	....
	Fine	Dry	92.0	98.6	103.4	103.8	98.9	90.0	91.4	99.7	....
		Wet	79.3	91.8	95.5	100.5	93.6	69.4	78.2	81.7	....
1 cu. ft. rd..	Coarse	Dry	100.4	108.0	111.6	111.2	106.2	96.3	100.8	106.6	....
		Wet	91.5	102.0	105.4	108.6	101.8	86.3	90.3	90.1	....
	Fine	Dry	91.1	98.4	102.7	102.9	97.4	91.3	91.0	98.6	....
		Wet	81.4	93.5	96.8	100.2	92.5	73.9	80.7	80.1	....
$\frac{1}{4}$ cu. ft. sq.	Coarse	Dry	100.2	107.2	109.9	109.7	105.7	95.0	98.2	108.1	....
		Wet	86.5	99.5	103.9	108.0	100.8	81.2	85.5	94.6	....
	Fine	Dry	89.4	97.4	101.7	102.2	97.1	87.6	89.1	100.0	....
		Wet	77.3	91.4	95.0	101.2	92.0	66.5	75.1	84.3	....
1 cu. ft. sq..	Coarse	Dry	101.6	109.3	112.4	111.4	103.9	98.5	98.0	108.1	....
		Wet	92.6	104.3	108.2	110.5	103.9	86.4	90.2	94.3	....
	Fine	Dry	91.6	98.6	103.7	103.5	98.2	89.4	91.1	99.9	....
		Wet	81.0	93.4	97.5	100.6	93.9	73.5	80.3	84.6	....

Note the general horizontal trend of the dry sand curves and the decided upward trend of the wet sand curves, indicating that when sand is measured dry, the size of the measure used has little effect on the unit weight obtained, while with wet sand the weight is markedly greater with larger measures, except in the case of Method H where there is a tendency toward the reverse of this rule.

It should be noted that with the $\frac{1}{4}$-cu. ft. size, the cylindrical measure gave slightly higher results generally than the cubical measure, while with the 1-cu. ft. size, the opposite is more generally true.

Curves I*b* show the average of the weights per cubic foot obtained by all laboratories with each sand and each size of measure plotted to "Pounds Per Cubic Foot" and "Method of Filling." These curves present in another form the same data that is given in Curves I*a*. The deductions to be drawn from them are better shown in later curves.

Attention may be directed, however, to the general similarity between all the curves for wet sand and the greater "flatness" of the curves for dry sand than for wet sand, indicating that the method of filling causes a greater difference in weight per cubic foot when wet sand is used than when dry sand is used.

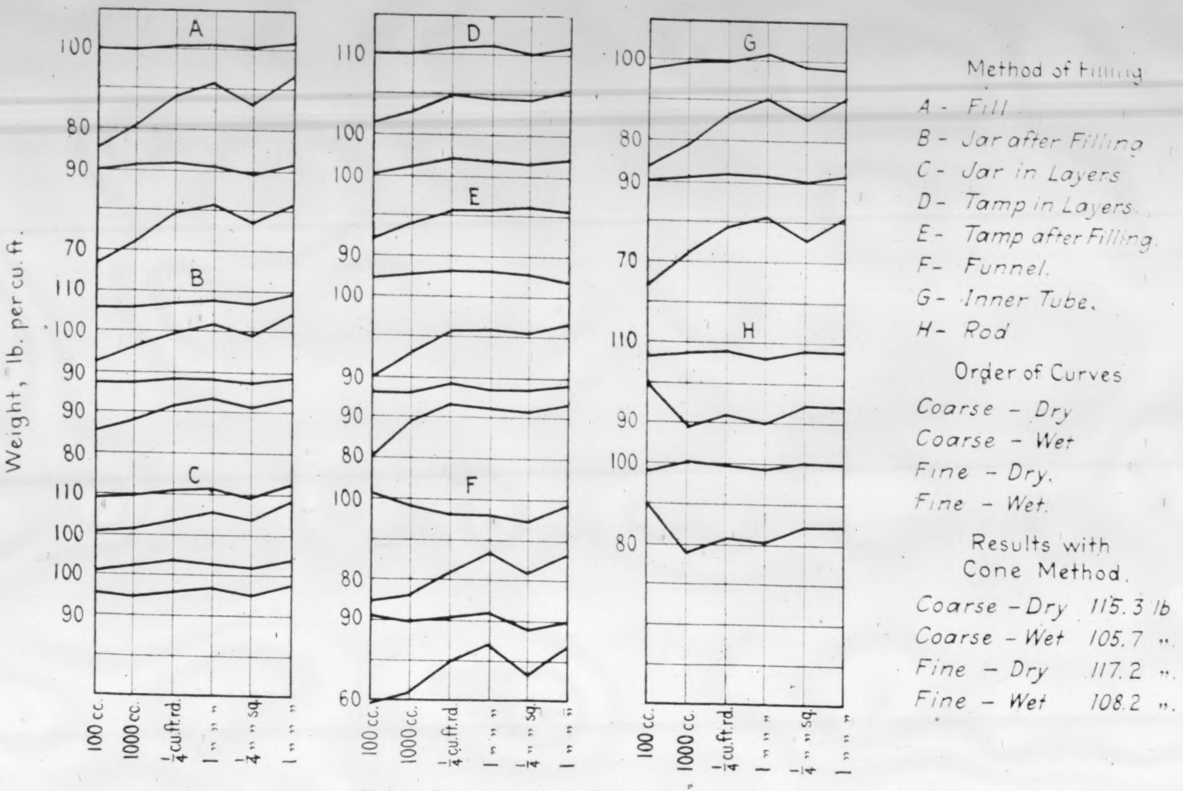
It is also to be noted that in the case of dry sand in small measures (100-cc. and 1000-cc.) the curves are flatter than for the same sand with larger measures, indicating a somewhat lesser effect due to method of filling when small measures are used.

TABLE II AND CURVES II.

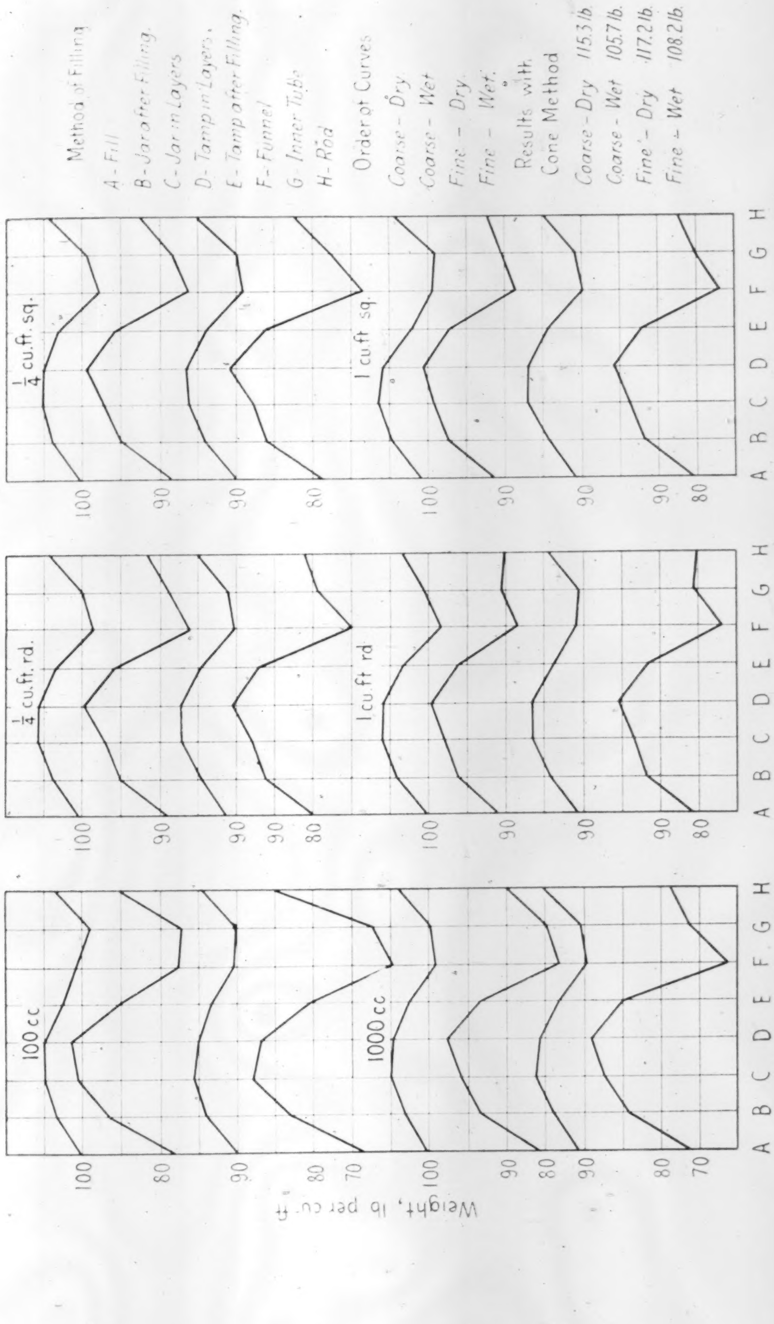
Table II is derived from Table I by averaging the six weights obtained with six sizes of measures for each kind of sand both wet and dry. The third line in Table II is the difference between the first and second lines of Table I and shows the difference in the average weights obtained with dry and wet sand of the same kind—that is, these figures represent the difference due to dampness. The sixth line is the difference between the fourth and fifth lines. The ninth line is the difference between the seventh and eighth lines. The last line is the average of the first, second, fourth and fifth lines.

The Curves II show the relation existing between the method of filling the measure and the resulting weight per cubic foot for both dry and wet sands and also the difference between the weights with dry and wet sands.

Attention is called to the markedly greater effect of method of filling when wet sand is used than when dry sand is used, as indicated by the greater difference between the high and low points on curves for wet sand than for curves for dry sand.



Curves I*a*.—Showing Effect of Size of Measure.



Curves I*b*.—Showing Effect of Method of Filling.

The lesser effect of method of filling is an argument for the use of dry sand in making unit weight determinations. A peculiarity in the relative effect on weight of Methods F and G should also be noted, namely, that with damp sand Method F gives much lower weights than method G while with dry sand the two methods give about equal results. A similar relation also exists between Methods C and D—namely, that while Method C gives slightly higher results than Method D, when dry sand is used, yet with wet sand Method D gives noticeably higher results than Method C.

In the curves showing difference between weights obtained on dry sand and on wet sand by the same method, it should be noted that these curves are almost complements of the curves above them showing weight per cubic foot. In other words, the method giving the highest weight per cubic foot (Method D) shows the least difference between the dry and wet results; and that the other methods are arranged in exactly the same order in the difference curves as in the weight curves.

TABLE II.—AVERAGE WEIGHTS FOR ALL LABORATORIES WITH ALL SIZES OF MEASURES.

Weight in pounds per cubic foot.

Sand.			Method.								
			A	B	C	D	E	F	G	H	Cone
Group A	Coarse	Dry	100.5	107.4	110.7	110.3	105.4	97.6	95.5	107.5	115.3
		Wet	85.8	99.1	104.0	107.3	99.1	69.6	84.4	93.4	105.7
		Dif.	14.7	8.3	6.7	3.0	6.3	28.0	11.1	14.1	9.6
	Fine	Dry	90.9	98.1	102.4	102.3	97.5	89.7	90.5	99.5	117.2
		Wet	76.3	90.8	95.9	99.0	90.2	67.5	75.2	82.9	108.2
		Dif.	14.6	7.3	6.5	3.3	7.3	22.2	15.3	16.6	9.0
Group B	Coarse and Fine	Dry	95.7	102.7	106.6	106.3	101.5	93.7	94.7	103.5	116.3
		Wet	81.1	95.0	99.9	103.1	94.6	74.2	79.8	88.7	107.0
		Dif.	14.6	7.7	6.7	3.2	6.9	19.5	14.9	15.3	9.3
Group C—Average of all			88.4	98.8	103.2	104.3	98.0	83.9	87.2	95.8	111.6

Attention is called to the high unit weight obtained with the Cone Method.

TABLES III AND CURVES III.

Table III is derived from Table I by averaging across the page the eight weights obtained with the eight methods for each kind of sand, both wet and dry. The third line in Table III is the difference between the first and second lines of Table I, and shows the difference in the average weights obtained with dry and wet sand of the same kind. That is, these figures represent the difference due to dampness. The sixth line is the difference between the fourth and fifth lines. The ninth line is the difference between the seventh and eighth lines. The last line is the average of the first, second, fourth and fifth lines.

These curves show the effect of the size of the measures used upon the unit weight for both dry and wet sand, and also the difference between the weight dry and the weight wet with the same size of measure.

Attention is directed to the increase in unit weight as the size of the measure is increased, particularly with the wet sand.

TABLE III.—AVERAGE WEIGHT FOR ALL LABORATORIES WITH ALL METHODS.

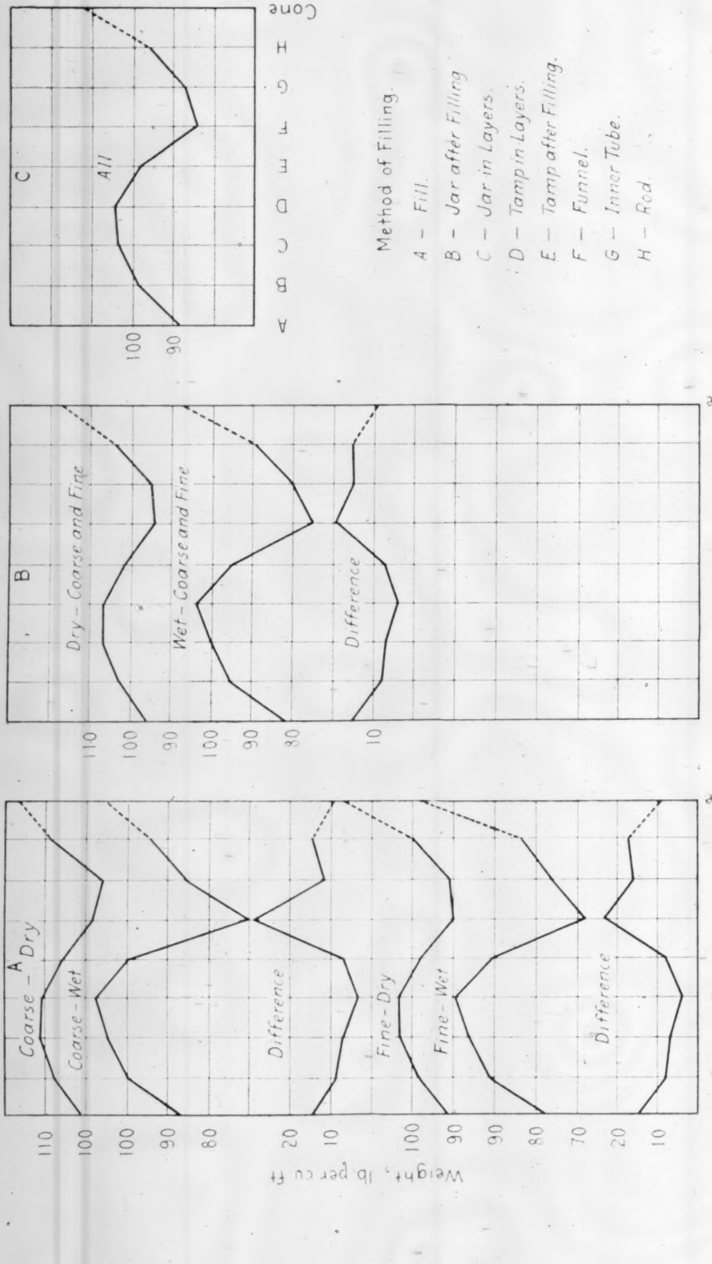
Weight in pounds per cubic foot.

Sand.			Measure.						
			100 cc.	1000 cc.	$\frac{1}{5}$ cu. ft. cone	$\frac{1}{4}$ cu. ft. Round.	1 cu. ft. Round.	$\frac{1}{4}$ cu. ft. Square.	1 cu. ft. Square.
Group A....	Coarse........	Dry	104.4	104.5	115.3	104.9	105.1	104.3	105.4
		Wet	88.6	90.8	105.7	95.4	96.8	95.0	98.8
		Dif.	15.8	13.7	9.6	9.5	8.3	9.3	6.6
	Fine..........	Dry	95.4	96.3	117.2	97.2	96.7	95.6	97.0
		Wet	79.4	81.8	108.2	86.3	87.4	85.4	88.1
		Dif.	16.0	14.5	9.0	10.9	9.3	10.2	8.9
Group B......	Coarse and Fine	Dry	99.9	100.4	116.3	101.1	100.9	100.0	101.2
		Wet	84.0	86.3	107.0	90.9	92.1	90.2	93.5
		Dif.	15.9	14.1	9.3	10.2	8.8	9.8	7.7
Group C—Average of all............			92.0	93.4	111.6	96.0	96.5	95.1	97.3

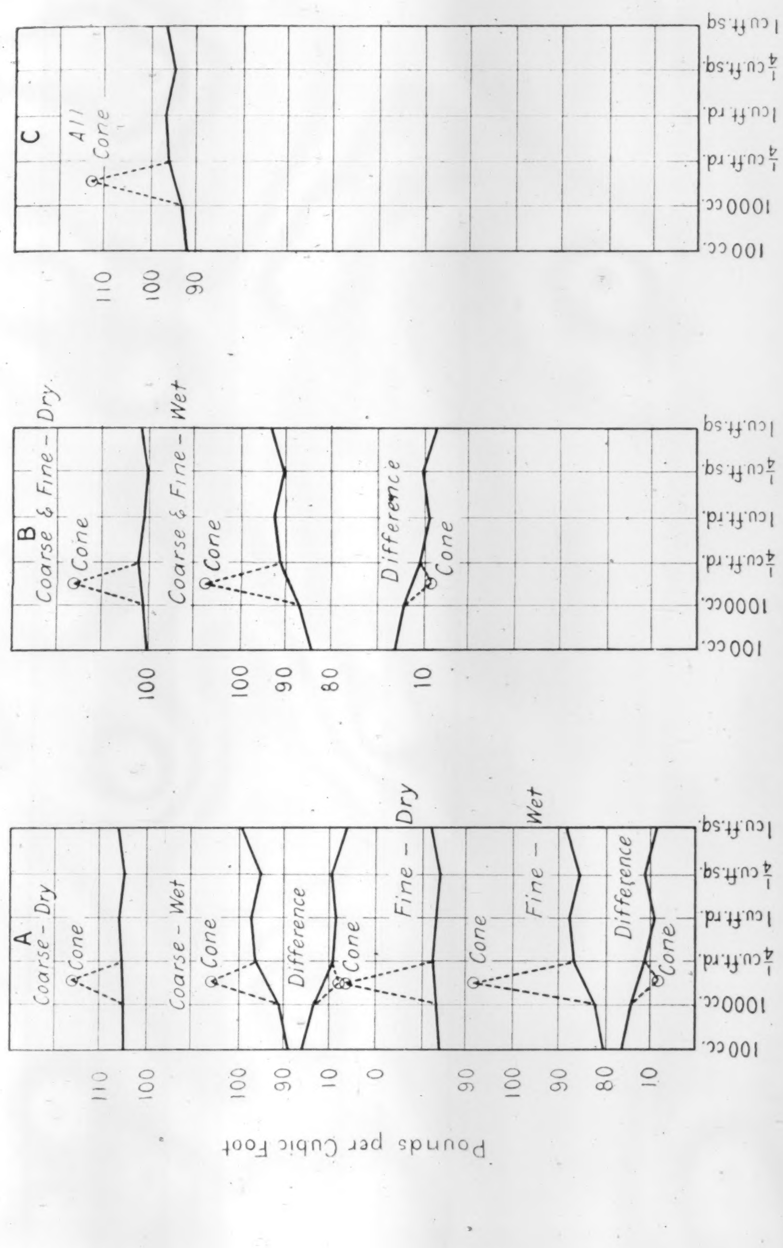
If we except the Cone Method, we note that dry sand gives nearly uniform weights with all sizes of measure, the largest measure averaging less than 2 lb. more than the smallest measure. The wet sand shows considerable difference due to size of measure, the largest measure averaging 11 to 12 lb. per cu. ft. higher than the smallest measure.

As the Cone Method was used with only one size of measure and with only one method of filling it cannot properly be averaged into this diagram. But as the capacity of the cone was about, 0.2 cu. ft., the results are indicated between the 1000-cc. and the $\frac{1}{4}$-cu. ft. round measures as a matter of interest.

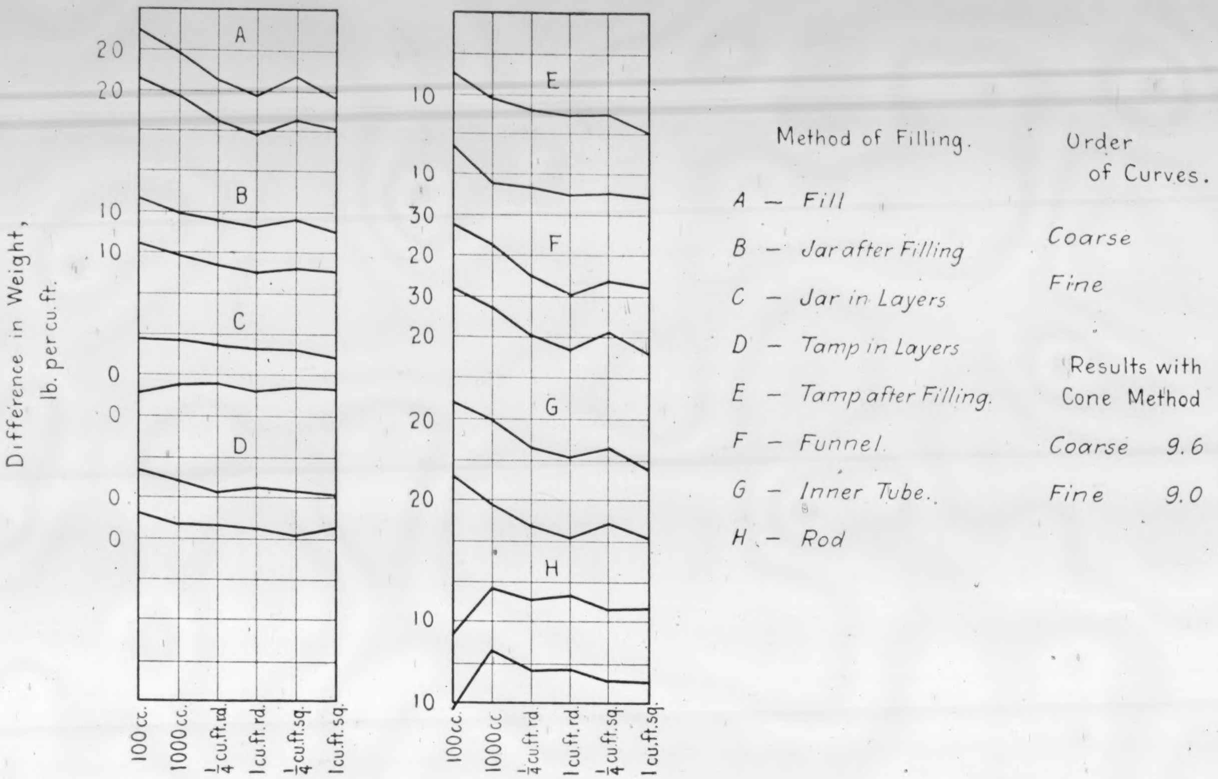
Attention is also called to the curve showing difference between the weight of dry sand and wet sand with the same



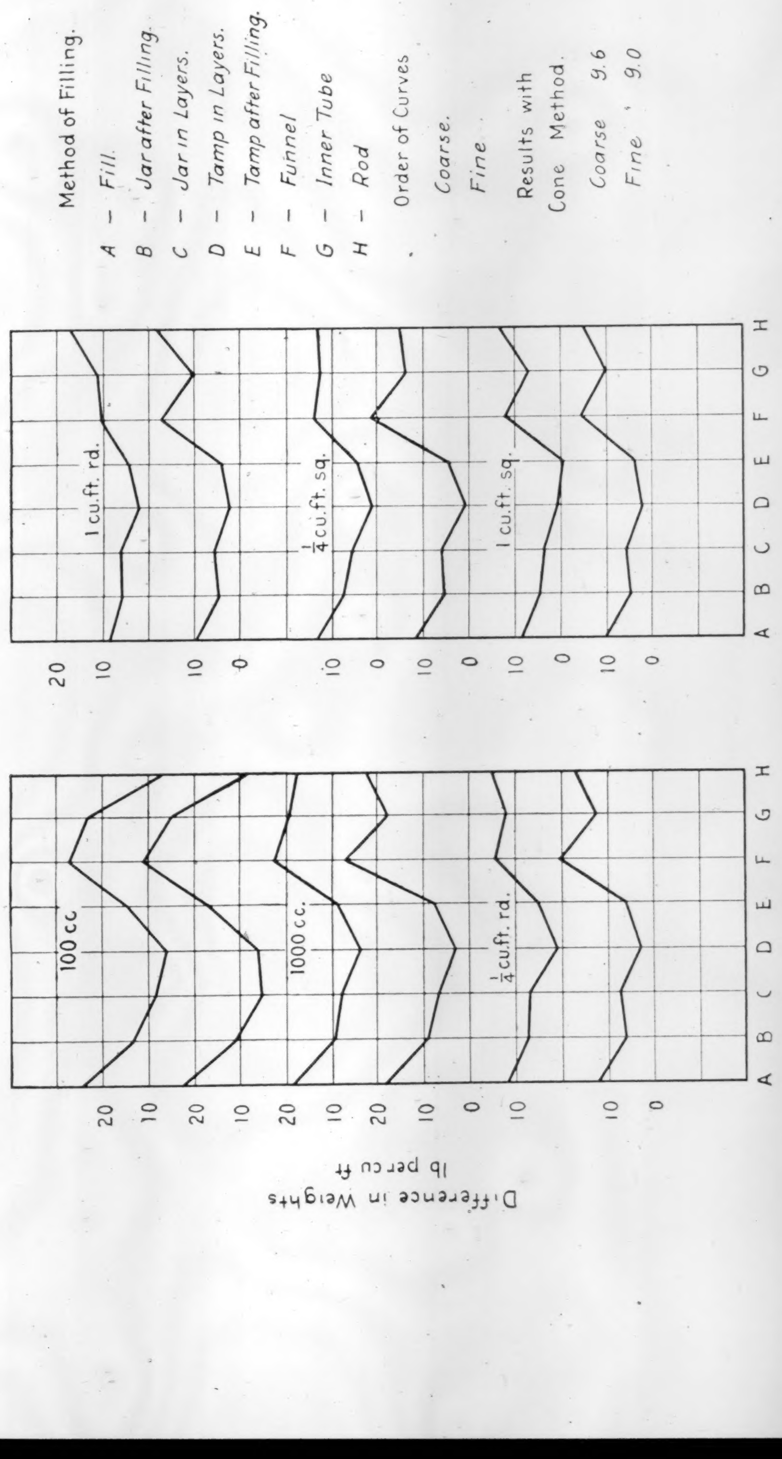
Curves II.—Showing Effect of Method of Filling and Effect of Dampness.



Curves III—Showing Effect of Size of Measure and Difference Due to Dampness.



Curves IV*a*.—Showing Effect of Size of Measure on Difference Due to Dampness.



Curves IV*b*.—Showing Effect of Method of Filling on Difference Between Dry and Damp Weight.

size of measure, by which it is clearly indicated that this difference is much more marked in the case of small measures than with large measures, and also that there is practically the same difference with cylindrical measures as with cubical measures.

The curves show that if sand is weighed dry, the capacity of the measure has little effect upon the result, but if weighed wet, small measures give lower results than large measures, and that if sand is weighed wet, the larger measures give results more nearly approaching the dry weight than small measures.

Again the high unit weight of the sand by the Cone Method is to be noted.

TABLE IV AND CURVES IV*a* AND IV*b*.

Table IV is derived from Table I. The figures in the first line of this table are the algebraic differences between the first and second lines of Table I. The second line of this table gives the differences between the third and fourth lines of Table I and so on.

Curves IV*a* show the effect of size of measure on the difference between the weight of sand as measured dry and wet. Attention is called to the fact that in no case does wet sand weigh more than the same dry sand and that the excess of the weight determined dry over the weight determined wet is greatest in the small measures and least in the large measures. Also there is little to choose between the cylindrical and cubical measures as regards the variation in results due to moisture in the sand.

Attention is also called to the lessening difference between the weight of sand as measured dry and the same sand measured wet as the size of measure is increased, except with Method H where the opposite case holds as regards the 100-cc. measure.

This greater difference for the small measures is more pronounced in the cases of Methods A, F, and G, than for Methods B, C, D, E, H, and Cone. It appears that the methods which compact the sand the least, and therefore give the lowest unit weights, show the greatest difference, while the methods which give the highest unit weight, because the sand is well jarred or tamped into the measure, give the least difference between dry weight and wet weight and also the least variation in this difference due to size of measure.

Curves IV*b* show the relation between method of filling measure and the difference between weight dry and weight wet of the same sand.

Attention is directed to the low value of these curves for Method D and the relatively high values for Method F. This indicates that moisture content of the sand when tested has least effect upon results when Method D is used and greatest effect when Method F is used.

TABLE IV.—ALGEBRAIC EXCESS IN WEIGHT OF DRY OVER WET SANDS FOR ALL LABORATORIES.

Excess in pounds per cubic foot.

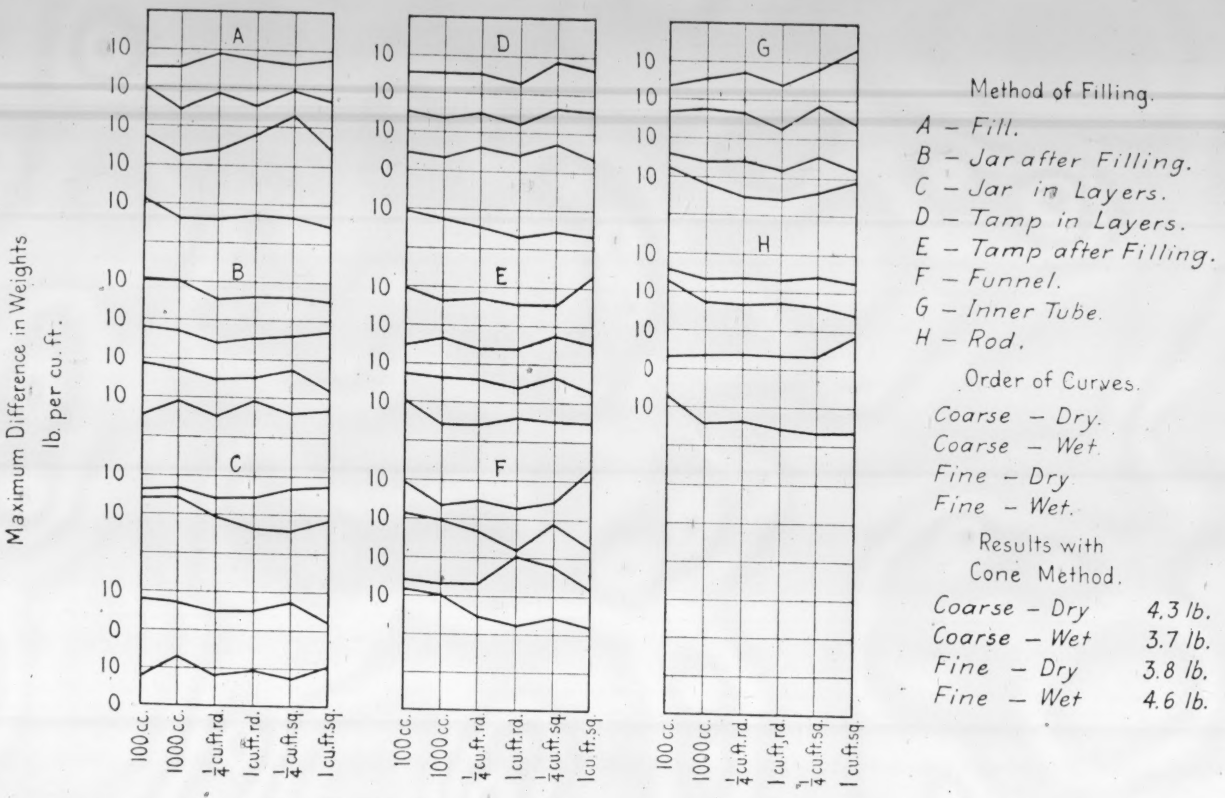
Measure.	Sand.	Method.									
		A	B	C	D	E	F	G	H	Cone	Average
100 cc	Coarse	24.9	13.5	8.8	6.9	14.7	27.1	23.7	7.0	....	15.8
	Fine	23.0	11.6	5.4	6.2	16.3	31.2	25.4	8.9	....	16.0
	Average	24.0	12.6	7.1	6.6	15.5	29.2	24.6	8.5	....	....
1000 cc	Coarse	19.1	9.7	8.2	4.2	8.8	22.2	19.5	18.0	....	13.7
	Fine	19.2	9.4	7.4	3.7	7.7	27.1	18.1	23.0	....	14.5
	Average	19.2	9.6	7.8	4.0	8.3	24.7	18.8	20.5	....	....
1/5 cu. ft. cone	Coarse	....	....	....	....	....	....	....	....	9.6	9.6
	Fine	....	....	....	....	....	....	....	....	9.0	9.0
	Average	....	....	....	....	....	....	....	....	9.3	....
1/4 cu. ft. rd	Coarse	12.2	7.6	7.2	1.7	5.3	14.8	12.4	15.4	....	9.6
	Fine	12.7	6.8	7.9	3.3	6.3	20.6	13.2	18.0	....	10.0
	Average	12.5	7.2	7.6	2.5	6.3	17.7	12.8	16.7	....	....
1 cu. ft. rd	Coarse	8.9	6.0	6.2	2.6	4.4	10.0	10.5	16.5	....	8.1
	Fine	9.7	4.9	5.9	2.7	4.9	17.4	10.3	18.5	....	9.3
	Average	9.3	5.5	6.1	2.7	4.7	13.7	10.4	17.5	....	....
1/4 cu. ft. sq	Coarse	13.7	7.7	6.0	1.7	4.9	13.8	12.7	13.5	....	9.3
	Fine	12.1	6.0	6.7	1.0	5.1	21.1	14.0	15.7	....	10.2
	Average	12.9	6.9	6.4	1.4	5.0	17.5	16.4	14.6	....	....
1 cu. ft. sq	Coarse	9.0	5.0	4.2	0.9	0.0	12.1	7.8	13.8	....	6.6
	Fine	10.6	5.2	6.2	2.9	4.3	15.9	10.8	15.3	....	8.9
	Average	9.8	5.1	5.2	1.9	2.2	14.0	9.3	14.6	....	....
Grand Average		14.8	7.8	6.7	3.2	6.9	19.4	14.9	15.3	9.3	....

TABLE V AND CURVES V*a* AND V*b*.

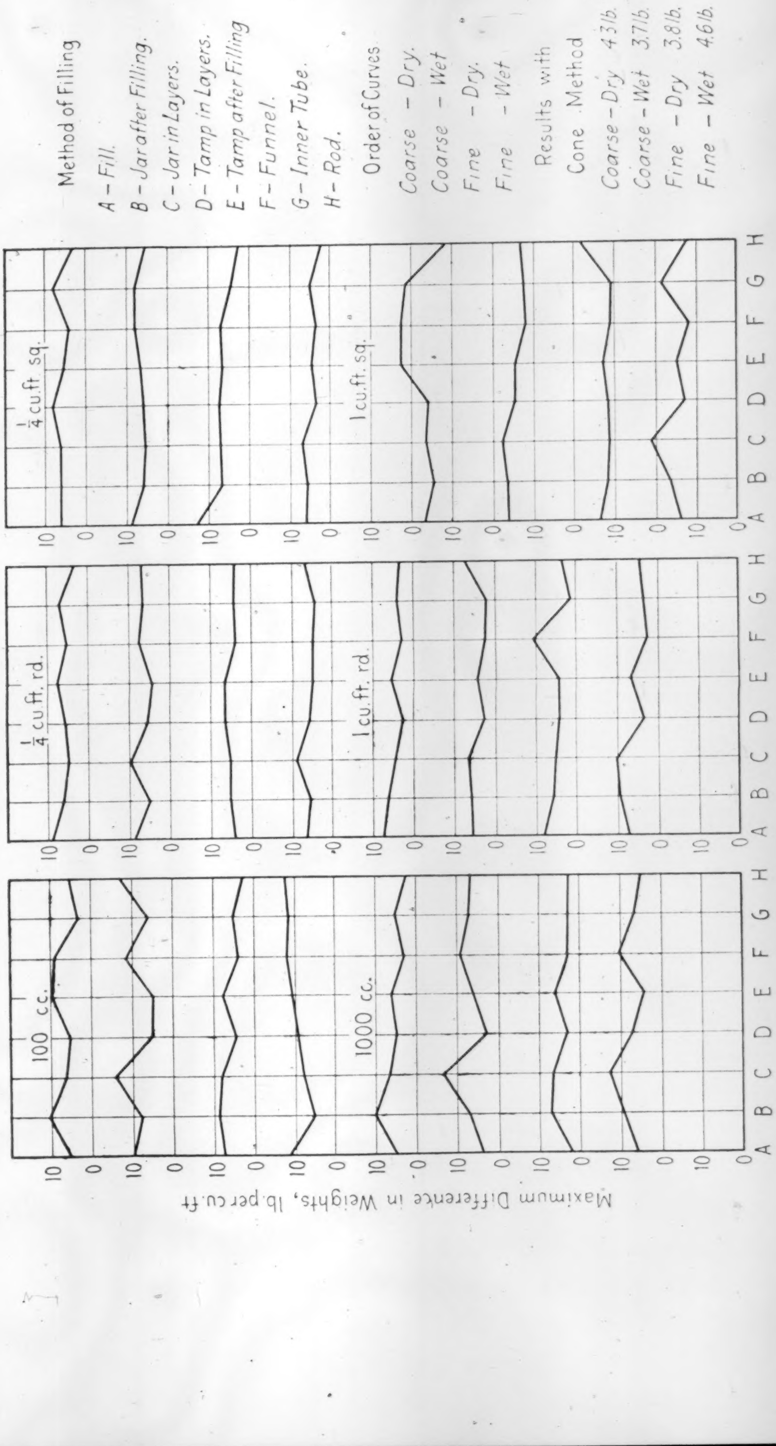
Table V shows the difference between the highest and lowest unit weights obtained by all laboratories. This is called the maximum difference.

Curve V*a* shows the relation existing between the size of the measure used and the maximum difference.

Curve V*b* shows the relation between the method of filling and the maximum difference.



Curves V*a*.—Showing Effect of Size of Measure on Maximum Difference in Weight.



Curves *Vh.*—Showing Effect of Method of Filling on Maximum Difference in Weight.

A superficial study of these curves fails to show any definite relation between either the size of the measure or the method of filling it, and the maximum range of results by different operators. It appears from these curves that the maximum range of results is approximately as great with one size of measure as with another and regardless of the method of filling. The reason these curves do not show any particular trend is because the variations due to size and method of filling are not consistent enough to stand out prominently when plotted in this manner.

TABLE V.—DIFFERENCE BETWEEN HIGHEST AND LOWEST WEIGHTS OBTAINED IN ALL LABORATORIES.

Differences in weights per cubic foot.

Measure.	Sand.		Method.									
			A	B	C	D	E	F	G	H	Cone	Average
100 cc	Coarse	Dry	5.1	10.6	6.3	5.3	9.8	9.6	3.5	5.4	...	7.0
		Wet	10.1	8.3	14.2	5.1	5.0	11.3	6.2	12.7	...	9.1
	Fine	Dry	7.8	9.0	8.1	4.7	7.9	4.1	5.5	3.0	...	6.3
		Wet	11.6	5.6	8.1	9.7	10.8	12.0	11.9	12.6	...	10.3
1000 cc	Coarse	Dry	5.2	10.1	7.0	5.2	6.7	3.6	5.9	3.2	...	5.9
		Wet	4.4	7.9	14.8	3.7	6.9	9.8	7.4	7.1	...	7.8
	Fine	Dry	2.7	7.7	7.2	3.8	6.8	3.5	3.3	3.3	...	4.8
		Wet	6.4	9.7	13.4	7.4	4.9	10.6	7.1	5.9	...	8.2
1/5 cu. ft. cone	Coarse	Dry	...	...	...	...	...	...	...	...	4.3	4.3
		Wet	...	...	...	...	...	...	...	...	3.7	3.7
	Fine	Dry	...	...	...	...	...	...	...	...	3.8	3.8
		Wet	...	...	...	...	...	...	...	...	4.6	4.6
1/4 cu. ft. rd	Coarse	Dry	8.9	5.9	4.4	5.1	7.4	5.0	7.4	3.8	...	6.0
		Wet	8.9	4.8	9.5	5.1	4.0	7.0	6.1	6.8	...	6.5
	Fine	Dry	3.9	5.0	5.0	6.1	6.2	3.6	4.0	3.9	...	4.7
		Wet	6.2	5.6	8.8	5.5	4.9	4.8	4.1	6.4	...	5.8
1 cu. ft. rd	Coarse	Dry	7.5	6.3	4.5	2.9	5.7	3.0	4.1	3.4	...	4.7
		Wet	5.3	6.0	6.7	2.6	4.2	2.2	2.1	7.3	...	4.6
	Fine	Dry	8.0	5.5	5.1	4.1	4.4	10.5	1.6	3.5	...	5.3
		Wet	7.2	9.6	9.8	3.1	6.6	2.4	3.6	4.7	...	5.9
1/4 cu. ft. sq	Coarse	Dry	6.3	6.3	6.9	8.7	5.9	4.9	8.8	4.1	...	6.5
		Wet	9.4	6.7	6.1	6.5	7.4	8.7	8.7	6.4	...	7.5
	Fine	Dry	13.1	7.4	7.9	8.1	7.3	8.1	5.2	3.6	...	7.6
		Wet	6.8	6.4	7.8	4.7	5.8	4.8	5.9	3.4	..	5.7
1 cu. ft. sq	Coarse	Dry	7.5	5.2	7.1	6.8	13.1	13.3	12.6	2.7	...	8.5
		Wet	7.0	7.6	8.6	5.7	5.7	2.9	3.4	4.5	...	5.7
	Fine	Dry	4.8	2.8	2.3	2.7	3.9	2.0	2.0	8.8	...	3.7
		Wet	4.4	7.2	10.9	3.5	5.4	2.5	8.9	3.3	...	5.8
Average			7.0	7.0	7.9	5.3	6.5	6.3	5.8	5.4	4.1	..

TABLE VI AND CURVES VI.

Table VI is derived from Table V. Group A is obtained by averaging the six weights obtained with six sizes of measures for each kind of sand, wet and dry. Group B is derived from Group A by averaging the first and third, and the second and fourth lines respectively. Group C is the average of Lines 1, 2, 3, and 4 of Group A.

Curves VI show the effect of method of filling on the maximum range of results obtained.

Attention is directed to the much greater maximum range shown for the wet sand than for the dry sand. This is one argument in favor of using dry sand in making weight determinations. It should also be noted that Method D gives less range of results than any other method except the Cone Method, and that Method H is second in this respect, while Method C gives the greatest range of results.

TABLE VI.—AVERAGE OF DIFFERENCES BETWEEN HIGHEST AND LOWEST WEIGHTS OBTAINED BY ALL LABORATORIES WITH ALL SIZES OF MEASURES.

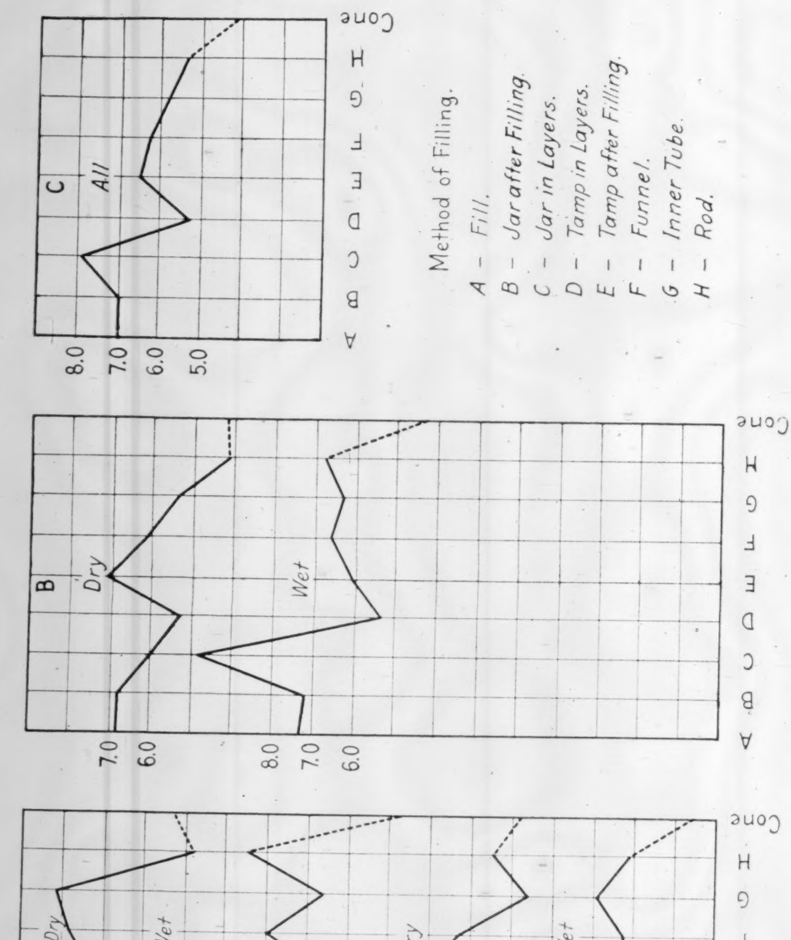
Differences in weight per cubic foot.

Sand.			Method.								
			A	B	C	D	E	F	G	H	Cone
Group A	Coarse	Dry	6.8	7.4	6.0	5.7	8.1	6.8	7.1	3.8	4.3
		Wet	7.5	6.9	10.0	4.8	5.5	7.0	5.7	7.5	3.7
	Fine	Dry	6.7	6.2	5.9	4.9	6.1	5.3	3.6	4.4	3.8
		Wet	7.1	7.4	9.8	5.7	6.4	6.2	6.9	6.1	4.6
Group B	Coarse and Fine	Dry	6.8	6.8	6.0	5.3	7.1	6.1	5.4	4.1	4.1
		Wet	7.3	7.2	9.9	5.3	6.0	6.6	6.3	6.8	4.2
		Dif.	0.5	0.4	3.9	0.0	−1.1	0.5	0.9	2.7	0.1
Group C—Average of all.....			7.0	7.0	8.9	5.3	6.5	6.3	5.8	5.4	4.1

TABLE VII AND CURVES VII.

Table VII is derived from Table V. Group A is obtained by using the figures given in the right hand column of Table V headed "Average." Group B is the average of the first and third, and the second and fourth lines respectively of Group A. Group C is the average of Group A.

Curves VII show the effect of the size and shape of the measure upon the maximum range of the results obtained.



Curves VI.—Showing Effect of Method of Filling on Range of Weights.

Attention is directed to the general lower range of the larger measures than of the smaller measures. The difference due to size and shape of measure is not great, but is fairly consistent and is somewhat greater for the cubical measures than for the cylindrical measures.

Again the Cone Method shows the lowest range of results, but as this method was used with only one size of measure, the results do not properly belong in this diagram and are inserted only as a matter of interest.

TABLE VIII AND CURVES VIII.

Table VIII is derived from Table V by subtracting the wet weight from the dry weight obtained with the same sand. For example, the first line of Table VIII is obtained by subtracting the second line of Table V from the first line of Table V. The averages shown in this table are algebraic averages.

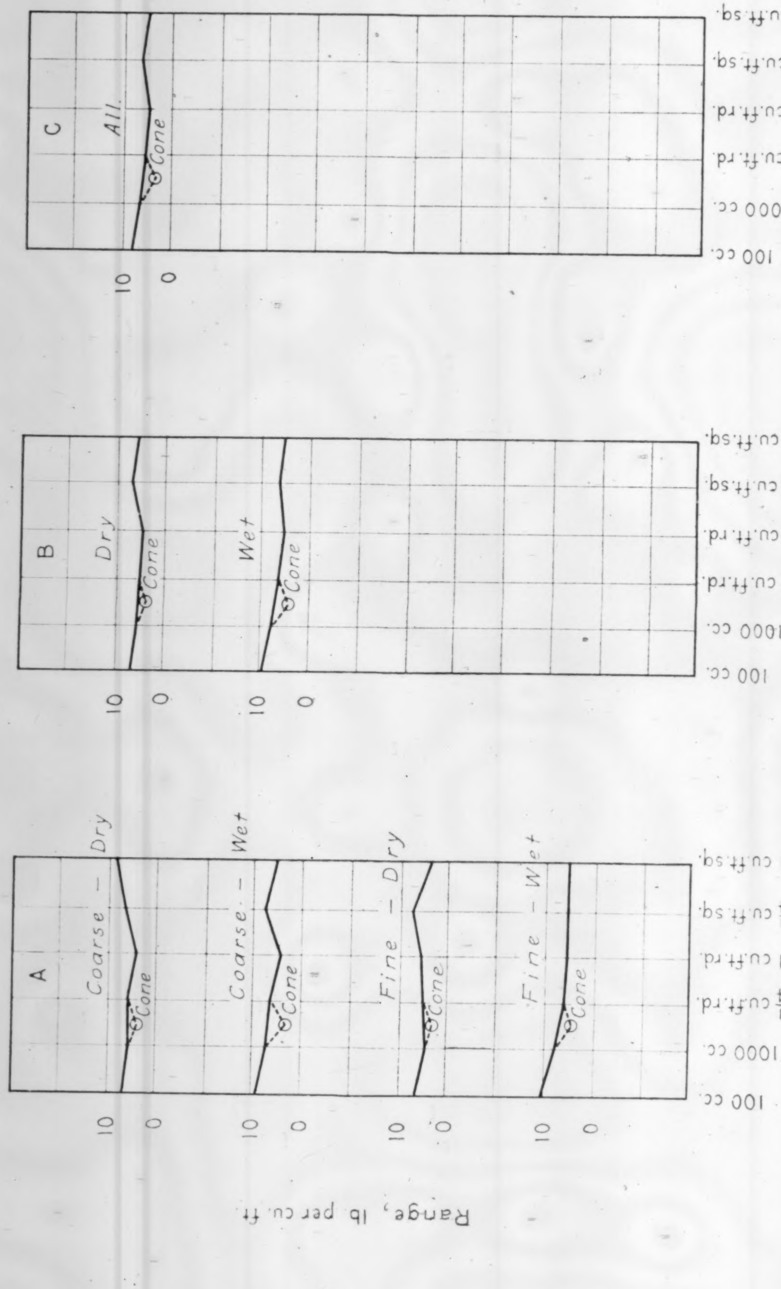
TABLE VII.—AVERAGE DIFFERENCE BETWEEN HIGHEST AND LOWEST WEIGHTS OBTAINED BY ALL LABORATORIES BY ALL METHODS.

Differences in weights per cubic foot.

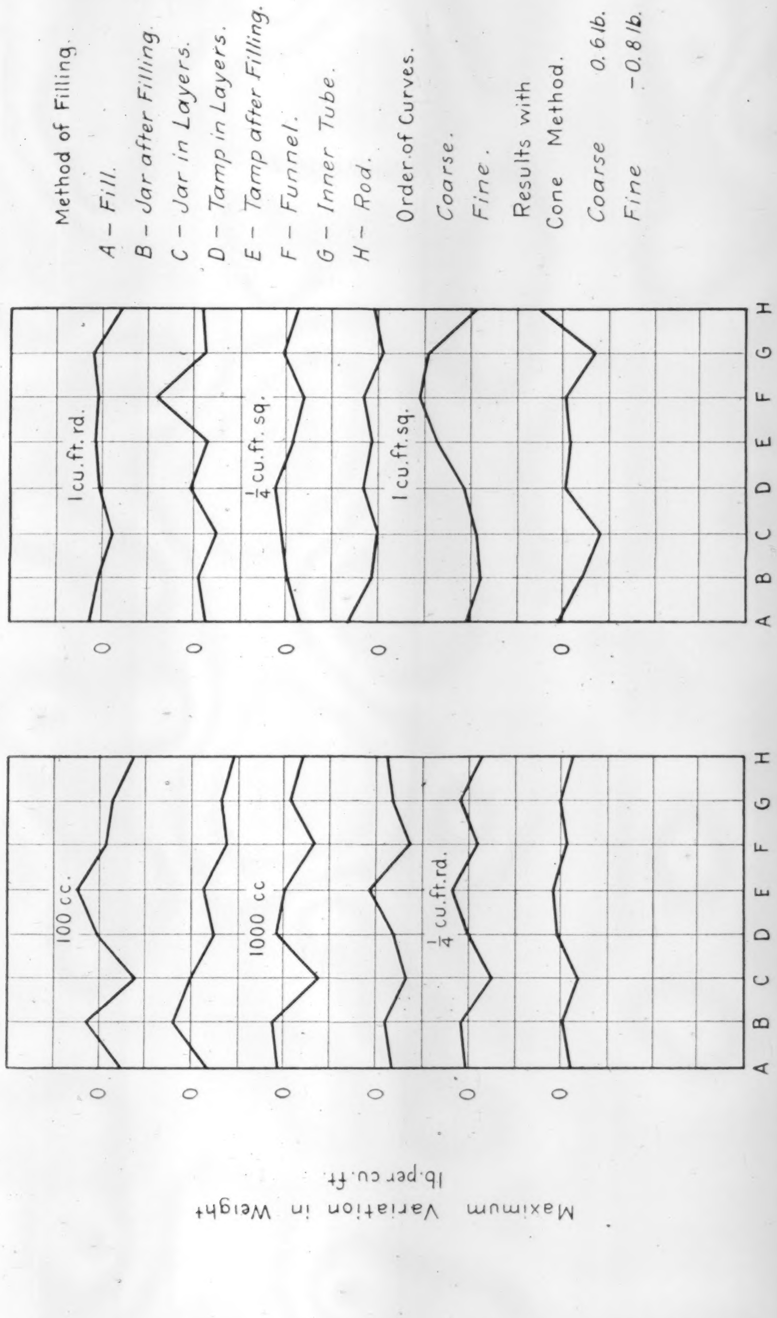
Sand.			Measure.						
			100 cc.	1000 cc.	$\frac{1}{5}$ cu. ft. Cone	$\frac{1}{4}$ cu. ft. Round	1 cu ft. Round	$\frac{1}{4}$ cu. ft. Square	1 cu ft. Square
Group A....	Coarse........	Dry	7.0	5.9	4.3	6.0	4.7	6.5	8.5
		Wet	9.1	7.8	3.7	6.5	4.6	7.5	5.7
	Fine..........	Dry	6.3	4.8	3.8	4.7	5.3	7.6	3.7
		Wet	10.3	8.2	4.6	5.8	5.9	5.7	5.8
Group B....	Coarse and Fine	Dry	6.7	5.4	4.1	5.4	5.0	7.1	6.1
		Wet	9.7	8.0	4.2	6.2	5.3	6.6	5.8
		Dif.	3.0	2.6	0.1	0.8	0.3	−0.5	0.3
Group C—Average of all............			8.2	6.7	4.1	5.8	5.1	6.8	5.9

Curves VIII show the algebraic excess of the difference between the highest and lowest weights for wet sand. Separate curves are shown for the coarse and fine sand. This shows that a slightly greater variation is usually obtained when wet sand is used than when dry sand is used.

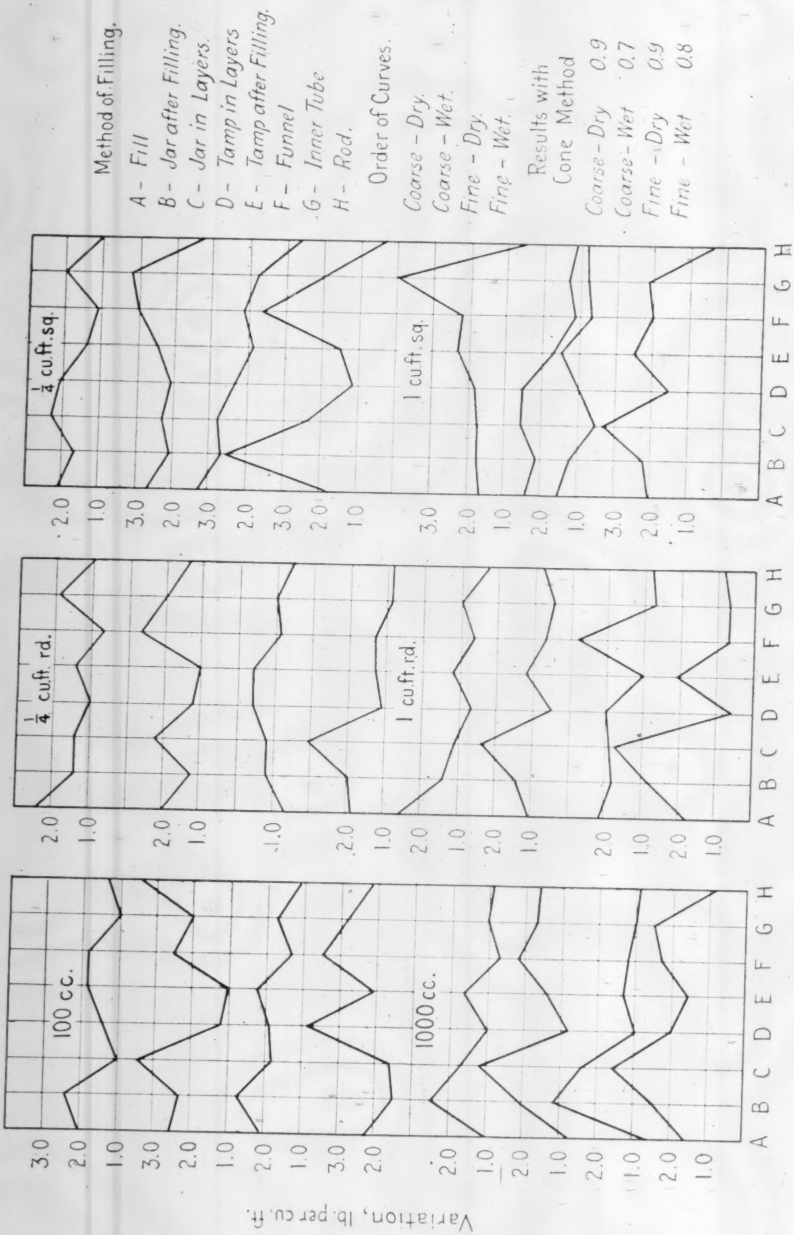
This is indicated in the table by the preponderance of negative signs and in the curves by the greater number of points lying below the zero line



Curves VII.—Showing Effect of Size of Measure on Range of Weights.



Curves VIII.—Showing Effect of Dampness on Maximum Variation in Weight.



Curves IXa.—Showing Effect of Method of Filling on Variation from the Mean Weight.

TABLE IX AND CURVES IX*a* AND IX*b*.

Table IX is obtained by taking the difference between eac of the five individual results obtained by each laboratory an the grand average of all laboratories, averaging these five differences to get the average variation for each laboratory, and then averaging these average variations for all laboratories.

Curves IX*a* show the relation between the method of filling and the mean variation from the average.

Curves IX*b* show the relation between the size of the measure and the mean variation from the average.

TABLE VIII—ALGEBRAIC EXCESS IN DIFFERENCE BETWEEN HIGHEST AND LOWEST WEIGHTS OF DRY OVER WET SANDS FOR ALL LABORATORIES.

Excess in pounds per cubic foot.

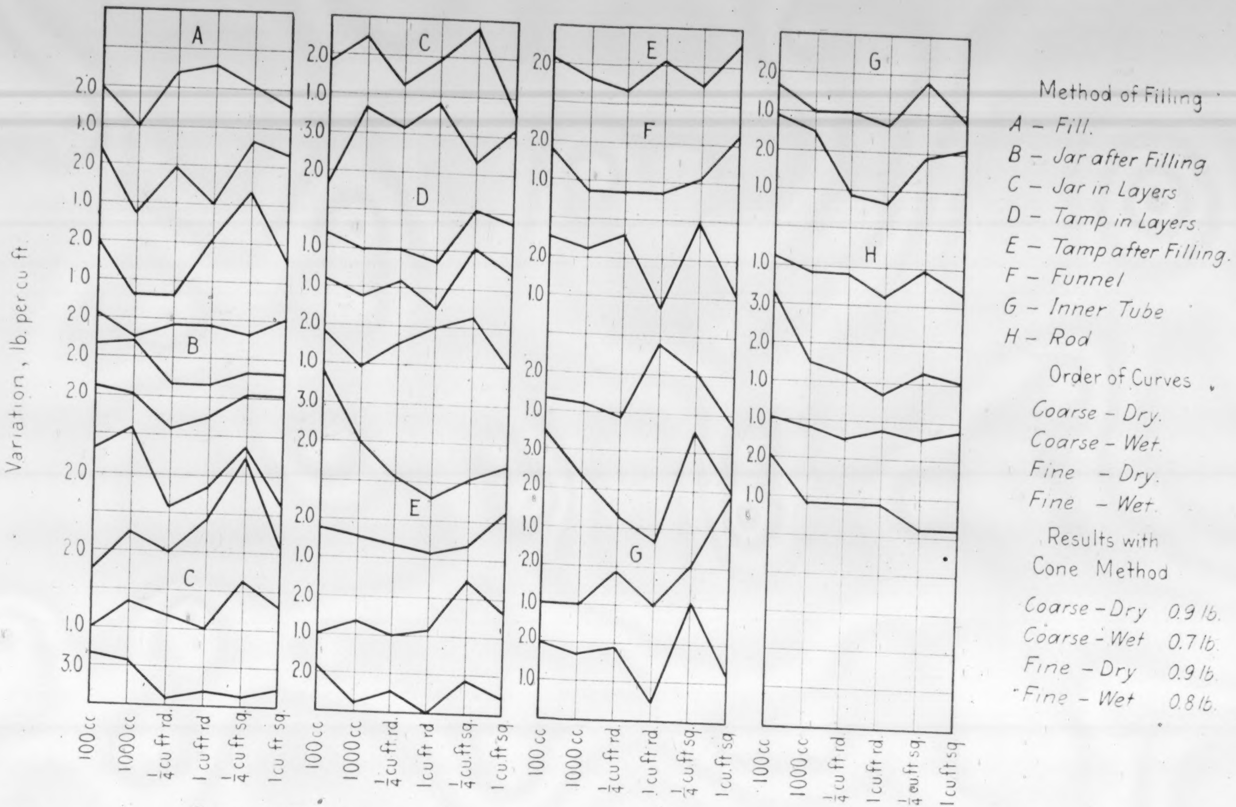
Measure.	Sand.	Method.									
		A	B	C	D	E	F	G	H	Cone	Average
100 cc	Coarse	−5.0	2.3	−7.9	0.2	4.8	−1.7	−2.7	−7.3	...	−2.2
	Fine	−3.8	3.4	0.0	−5.0	−2.9	−7.9	−6.4	−9.6	...	−4.0
1000 cc	Coarse	0.8	2.2	−7.8	1.5	−0.2	−6.2	−1.5	−3.9	...	−1.9
	Fine	−3.7	−2.0	−6.2	−3.6	1.9	−7.1	−3.8	−2.6	...	−3.4
$\frac{1}{5}$ cu. ft. cone	Coarse	...	...	...	...	...	...	...	...	0.6	0.6
	Fine	...	...	...	...	...	...	...	...	−0.8	−0.8
$\frac{1}{4}$ cu. ft. rd	Coarse	0.0	1.1	−5.1	0.0	3.4	−2.0	1.3	−3.0	...	−0.5
	Fine	−2.3	−0.8	−3.8	0.6	1.3	−1.2	−0.1	−2.5	...	−1.1
1 cu. ft. rd	Coarse	2.2	0.3	−2.2	0.3	1.5	0.8	2.0	−3.9	...	0.1
	Fine	−2.8	−0.6	−4.7	1.0	−2.2	8.1	−2.0	−1.2	...	−0.6
$\frac{1}{4}$ cu. ft. sq	Coarse	−3.1	−0.4	0.8	2.2	−1.5	−3.8	0.1	−2.3	...	−1.0
	Fine	6.3	1.0	0.1	3.4	1.5	3.3	−0.7	0.2	...	1.9
1 cu. ft. sq	Coarse	0.5	−2.4	−1.5	1.1	7.4	10.4	9.2	−1.8	...	2.9
	Fine	0.4	−4.4	−8.6	−0.8	−1.5	−0.5	−6.9	5.5	...	−2.1
Grand average		−0.6	−0.3	−2.9	0.1	0.8	−0.7	−1.0	−2.7	−0.1	....

Attention is directed to the lack of any marked or consistent trend in the curves, which indicates that none of the methods used has any very decided superiority over the others in giving uniformity of results.

Of them all, Method H appears to be most satisfactory inasmuch as it is adapted to more extensive use than the Cone Method, which gives slightly lower variation than Method H.

TABLE X AND CURVES X.

Table X is derived from Table IX. Group A is obtained by averaging the six averages obtained with the six sizes of measures for both coarse and fine sand, wet and dry.



Curves IX*b*.—Showing Effect of Size of Measure on Variation from Mean Weight.

Group B is the average of the first and third, and second and fourth lines respectively of Group A.

Group C is the average of Group A.

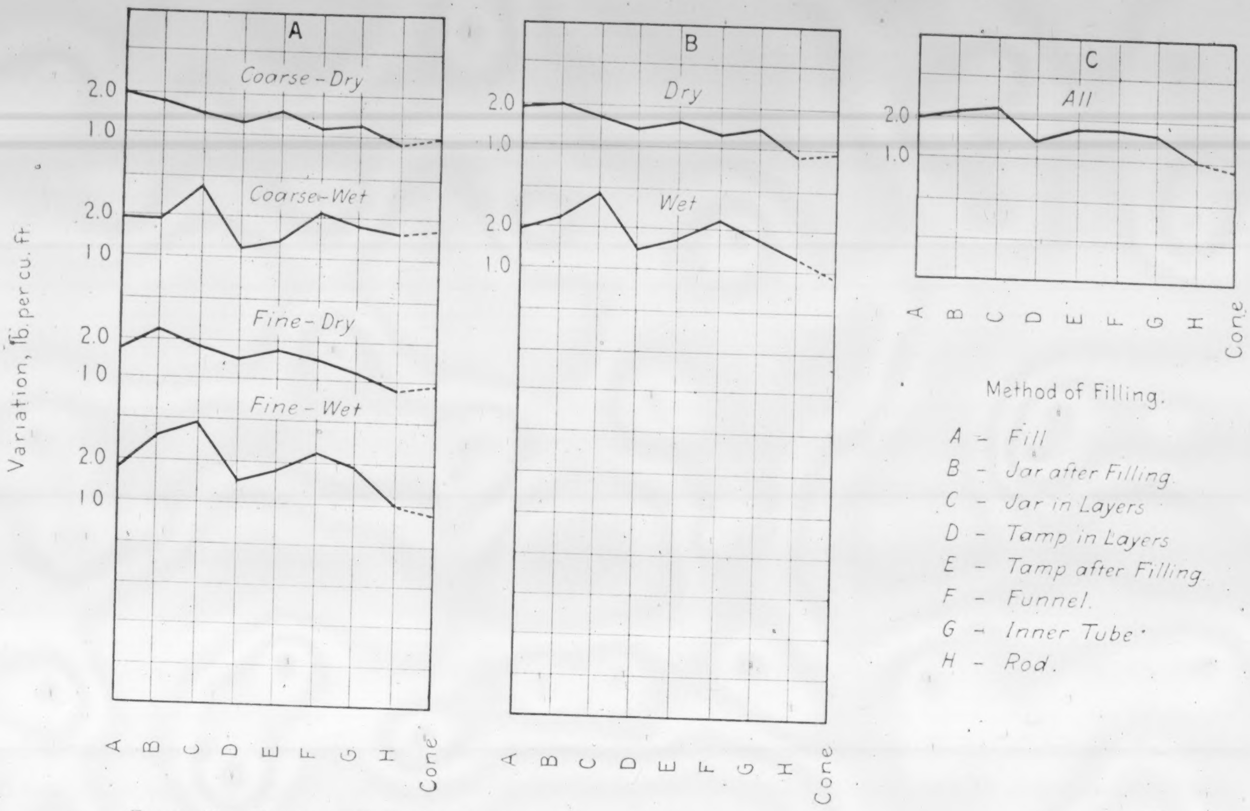
The curves show the relation between method of filling and the variation from the mean weight for the various sands.

TABLE IX.—AVERAGE FOR ALL LABORATORIES OF THE VARIATION FROM THE MEAN WEIGHT OF ALL LABORATORIES.

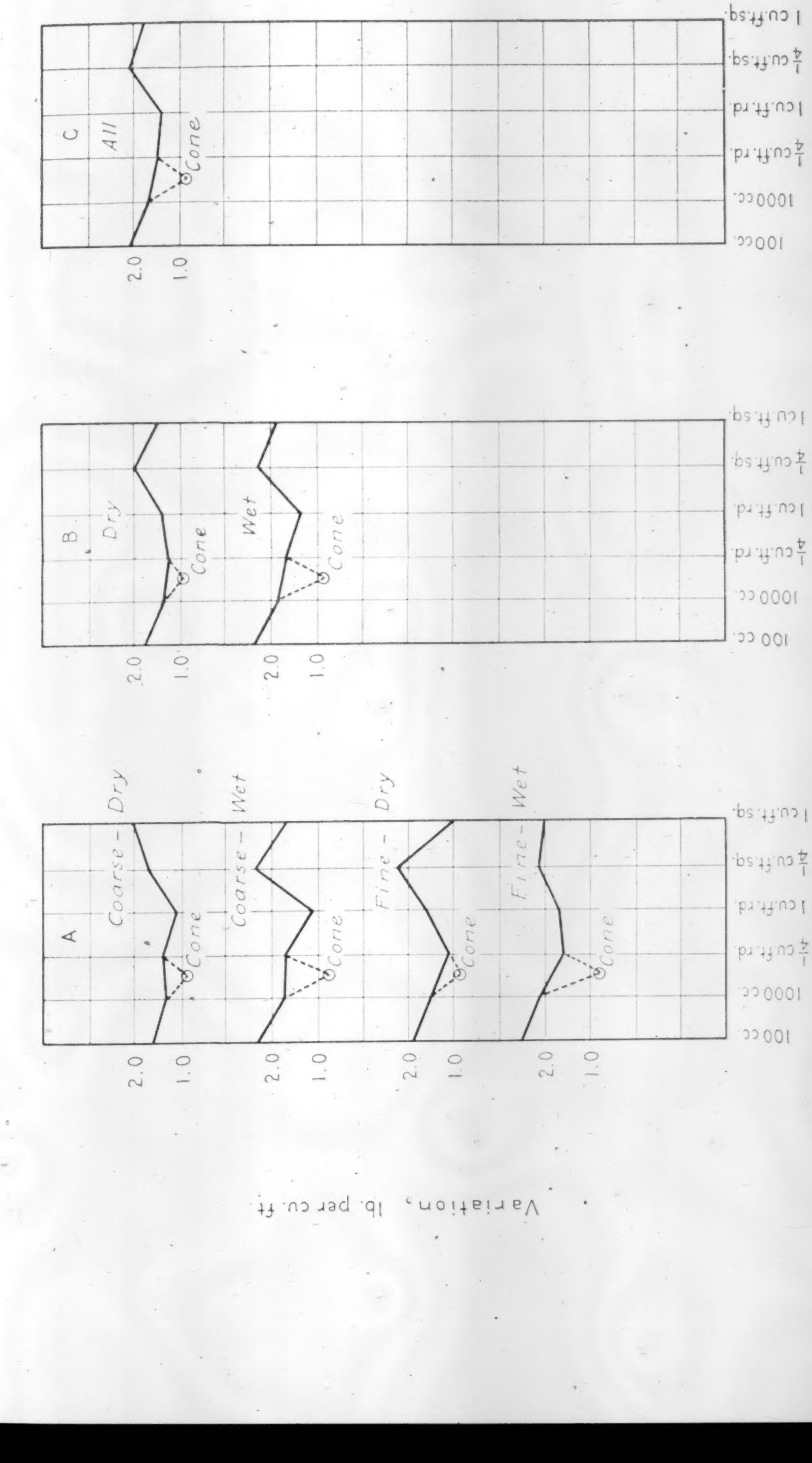
Variation in pounds per cubic foot.

Measure.	Sand.		Method.									
			A	B	C	D	E	F	G	H	Cone	Average
100 cc	Coarse	Dry	2.0	2.4	1.0	1.4	1.8	1.8	1.0	1.3	...	1.6
		Wet	2.5	2.3	3.4	1.2	1.0	2.5	2.0	3.4	...	2.3
	Fine	Dry	2.1	2.7	1.8	1.9	2.2	1.3	1.7	1.1	...	1.9
		Wet	2.2	1.5	1.6	3.9	2.1	3.5	2.9	2.2	...	2.5
1000 cc	Coarse	Dry	1.0	2.5	1.7	1.0	1.6	0.7	1.0	0.9	...	1.3
		Wet	0.8	2.1	3.2	0.8	1.4	2.2	1.7	1.6	...	1.7
	Fine	Dry	0.7	3.2	2.5	1.0	1.3	1.2	1.0	0.9	...	1.5
		Wet	1.6	2.5	3.6	2.0	1.6	2.3	2.5	0.9	...	2.1
$\frac{1}{5}$ cu. ft. cone	Coarse	Dry	...	...	...	...	...	...	...	...	0.9	0.9
		Wet	...	...	...	...	...	...	...	...	0.7	0.7
	Fine	Dry	...	...	...	...	...	...	...	...	0.9	0.9
		Wet	...	...	...	...	...	...	...	...	0.8	0.8
$\frac{1}{4}$ cu. ft. rd	Coarse	Dry	2.4	1.4	1.4	1.0	1.4	0.7	1.9	0.9	...	1.4
		Wet	2.0	1.2	2.2	1.2	1.0	2.6	1.9	1.3	...	1.7
	Fine	Dry	0.7	1.2	1.2	1.6	1.6	0.9	1.0	0.6	...	1.1
		Wet	1.9	2.0	3.1	1.1	1.3	1.3	0.9	0.9	...	1.6
1 cu. ft. rd	Coarse	Dry	2.6	1.4	1.1	0.7	1.2	0.7	1.0	0.3	...	1.1
		Wet	1.1	1.5	2.4	0.5	1.2	0.7	0.5	0.8	...	1.1
	Fine	Dry	2.1	1.8	1.9	2.0	1.0	2.8	0.7	0.8	...	1.6
		Wet	1.9	2.9	3.8	0.6	2.1	0.7	0.7	0.9	...	1.7
$\frac{1}{4}$ cu. ft. sq	Coarse	Dry	2.1	1.7	2.3	2.1	1.4	1.1	2.0	1.0	...	1.7
		Wet	2.7	2.1	2.3	2.1	2.5	3.0	3.2	1.3	...	2.4
	Fine	Dry	3.3	2.7	2.8	2.3	1.9	2.1	1.8	0.6	...	2.2
		Wet	1.7	4.5	2.3	1.1	1.5	3.6	1.9	0.3	...	2.1
1 cu. ft. sq	Coarse	Dry	1.6	1.7	1.7	1.8	2.3	2.2	3.9	0.4	...	2.0
		Wet	2.4	2.1	2.5	1.5	1.7	1.1	1.3	1.1	...	1.7
	Fine	Dry	1.5	1.2	0.5	1.0	1.5	0.7	0.8	0.8	...	1.0
		Wet	2.0	2.2	3.2	1.5	2.5	2.0	2.1	0.3	...	2.0
Grand Average			1.9	2.1	2.2	1.4	1.7	1.7	1.6	1.0	0.8	...

Attention is called to the low variation from the mean of Method H and the Cone Method for both dry and wet sand. Also, that while with dry sand either Method D or F give equally low variations from the mean (although Method D is one which gives the high unit weights, and Method F is one which gives lower



Curves X.—Showing Effect of Method of Filling and of Dampness on Variation from Mean Weight.



Curves XI.—Showing Effect of Size of Measure and Effect of Dampness on Variation from Mean Weight.

unit weights as shown in Curves of Tables I and II) yet with wet sand Method D gives noticeably more concordant results than Method F.

TABLE XI AND CURVES XI.

Table XI is derived from Table IX. Group A is the average of the eight averages obtained by the eight methods for both coarse and fine sand, wet and dry. Group B is the average of the first and third and the second and fourth lines of Group A. Group C is the average of Group A.

Curves XI show the relation between size and shape of measure and the average variation from the mean.

TABLE X.—AVERAGE FOR ALL LABORATORIES FOR ALL SIZES OF MEASURES OF THE VARIATION FROM THE MEAN WEIGHT OF ALL LABORATORIES.

Variation in pounds per cubic foot.

Sand.			Method.								
			A	B	C	D	E	F	G	H	Cone
Group A.....	Coarse	Dry	2.0	1.8	1.5	1.3	1.6	1.2	1.3	0.8	0.9
		Wet	1.9	1.9	2.7	1.2	1.4	2.1	1.8	1.6	0.7
	Fine	Dry	1.7	2.2	1.8	1.5	1.7	1.5	1.2	0.8	0.9
		Wet	1.8	2.6	2.9	1.5	1.8	2.2	1.9	0.9	0.8
Group B.....	Coarse and Fine	Dry	1.9	2.0	1.7	1.4	1.6	1.3	1.5	0.8	0.9
		Wet	1.9	2.2	2.8	1.4	1.7	2.2	1.8	1.3	0.8
		Dif.	0.0	0.2	1.1	0.0	0.0	0.9	0.3	0.5	0.1
Group C—Average of all.....			1.9	2.1	2.2	1.4	1.7	1.7	1.6	1.0	0.8

It should be noted that with cylindrical measures, the large sizes give less variation from the mean than the small sizes, and that large cubical measures are subject to greater variation in results than large cylindrical measures.

These curves indicate that cylindrical measures are to be preferred and that about ¼-cu. ft. is sufficiently large to give the most concordant results.

TABLE XII AND CURVES XII.

Table XII is derived from Table IX by subtracting the weight wet from the weight dry of coarse sand and fine sand. For example, the first line of Table XII is obtained by subtracting the second line of Table IX from the first line of Table IX.

Curves XII show the algebraic excess of the average variation from the mean obtained with dry sand over the average variation from the mean obtained with wet sand.

They indicate that there is somewhat greater average variation when wet sand is used than when dry sand is used. This fact is shown somewhat better by means of the table than it is by the curves. The preponderance of negative signs in the table shows the greater variation of the wet sand. In the curves, the greater portion lying below the zero line also indicates the same thing.

The entire lack of similarity between the curves indicates the variableness of the relation which the curves represent. The purpose of the table and curves is to show whether, with any particular method, there is greater variation from the mean when wet sand is used than when dry sand is used. None of the methods of filling show a systematically closer agreement with one sand or the other, that is, with dry or wet sand.

TABLE XI.—AVERAGE FOR ALL LABORATORIES FOR ALL METHODS OF THE VARIATION FROM THE MEAN WEIGHT OF ALL LABORATORIES.

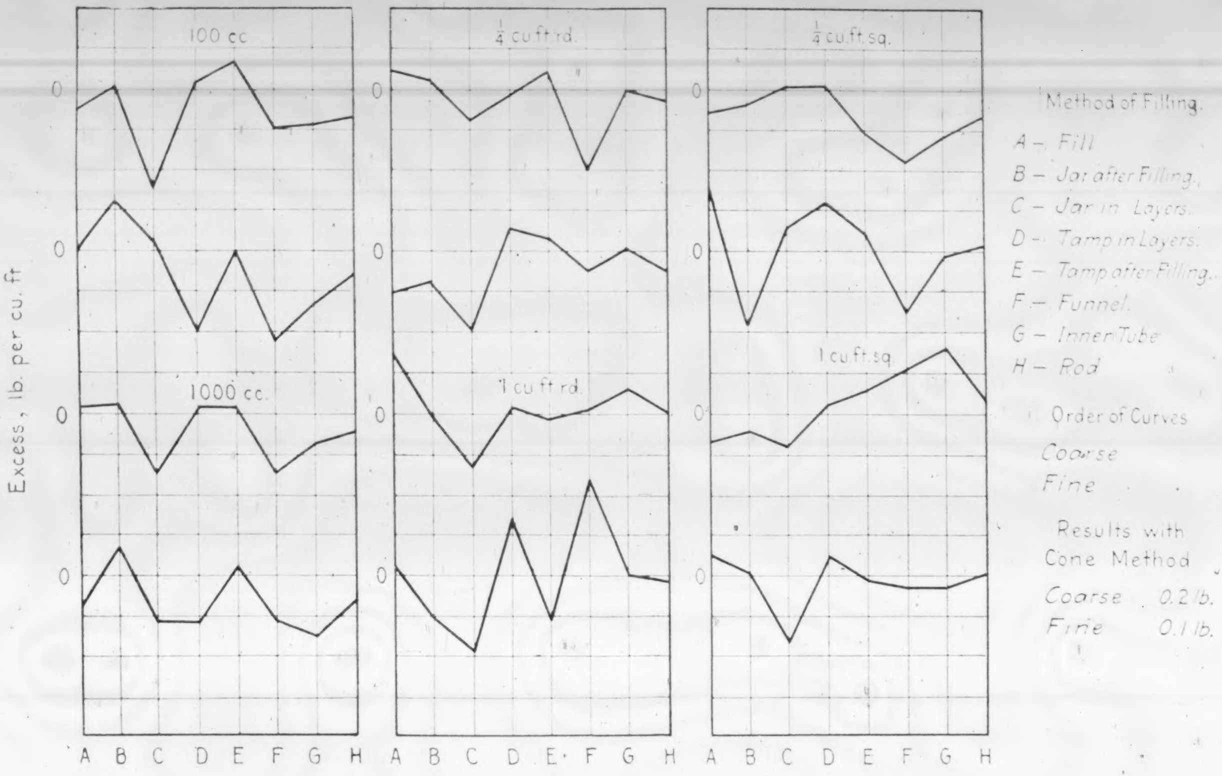
Variation in pounds per cubic foot.

Sand.			Measure.						
			100 cc.	1000 cc.	$\frac{1}{5}$ cu. ft. Cone	$\frac{1}{4}$ cu. ft. Round	1 cu. ft. Round	$\frac{1}{4}$ cu. ft. Square	1 cu. ft. Square
Group A....	Coarse........	Dry	1.6	1.3	0.9	1.4	1.1	1.7	2.0
		Wet	2.3	1.7	0.7	1.7	1.1	2.4	1.7
	Fine..........	Dry	1.9	1.5	0.9	1.1	1.6	2.2	1.0
		Wet	2.5	2.1	0.8	1.6	1.7	2.1	2.0
Group B....	Coarse and Fine	Dry	1.8	1.4	0.9	1.3	1.4	2.0	1.5
		Wet	2.4	1.9	0.8	1.7	1.4	2.3	1.9
		Dif.	0.6	0.5	0.1	0.4	0.0	0.3	0.4
Group C—Average of all...........			2.1	1.7	0.8	1.5	1.5	2.1	1.7

TABLE XIII AND CURVES XIII.

Table XIII is derived from Tables II and VI by taking section C from each of these tables and combining them in this table.

These data and the curves show the relation that exists between method of filling the measure and average weight per cubic foot and also the maximum variation and average variation from the mean.



Curves XII.—Showing Effect of Methods of Filling on Excess of Weight of Dry Sand over Wet Sand.

A study of these curves shows that for maximum unit weight the Cone Method should be used while for the lightest unit weight Method F should be used, the other methods ranging in between these two extremes.

As regards maximum variation, the Cone Method gives the least difference between highest and lowest results, closely followed by methods D and H, while Method C is most conducive to large variations.

TABLE XII.—ALGEBRAIC EXCESS IN AVERAGE VARIATION OF DRY OVER WET SANDS FOR ALL LABORATORIES.

Excess in pounds per cubic foot.

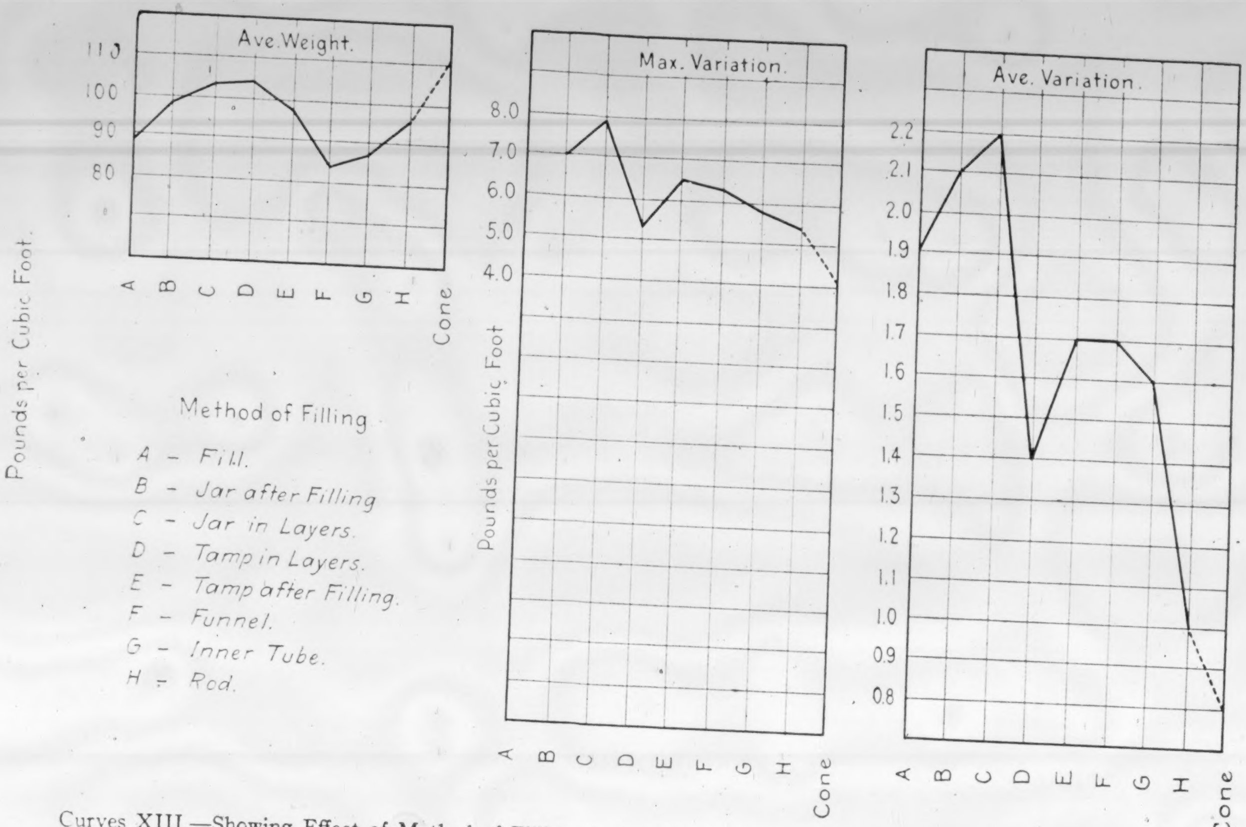
Measure.	Sand.	Method.									
		A	B	C	D	E	F	G	H	Cone	Average
100 cc.	Coarse	−0.5	0.1	−2.5	0.2	0.7	−1.0	−0.9	−0.7	...	−0.6
	Fine	0.0	1.2	0.2	−1.9	0.1	−2.2	−1.3	−0.6	...	−0.6
1000 cc.	Coarse	0.2	0.3	−1.5	0.2	0.2	−1.4	−0.7	−0.4	...	−0.4
	Fine	−0.8	0.8	−1.1	−1.1	0.3	−1.1	−1.5	−0.6	...	−0.6
$\frac{1}{5}$ cu. ft. cone	Coarse	...	...	...	...	...	...	...	...	0.2	0.2
	Fine	...	...	...	...	...	...	...	...	0.1	0.1
$\frac{1}{4}$ cu. ft. rd.	Coarse	0.4	0.2	−0.8	−0.2	0.4	−2.0	0.0	−0.3	...	−0.3
	Fine	−1.1	−0.8	−1.9	0.5	0.3	−0.5	0.0	−0.5	...	−0.5
1 cu. ft. rd.	Coarse	1.5	−0.1	−1.3	0.2	−0.1	0.1	0.6	0.0	...	0.1
	Fine	0.2	−1.1	−1.9	1.4	−1.1	2.2	0.0	−0.1	...	−0.1
$\frac{1}{4}$ cu. ft. sq.	Coarse	−0.6	−0.4	0.0	0.0	−1.1	−1.9	−1.2	−0.7	...	−0.7
	Fine	1.6	−1.8	0.5	1.1	0.4	−1.5	−0.1	0.1	...	0.0
1 cu. ft. sq.	Coarse	−0.7	−0.4	−0.8	0.2	0.6	1.1	1.6	0.3	...	0.2
	Fine	−0.5	−1.0	−2.7	−0.5	−1.1	−1.3	−1.3	−1.0	...	−1.2
Grand Average		−0.2	−0.1	−0.6	0.0	−0.2	−0.5	−0.4	−0.4	0.2	...

In the matter of average variation from the mean, it is the Cone Method again which gives most concordant results and Method C which gives least concordant results.

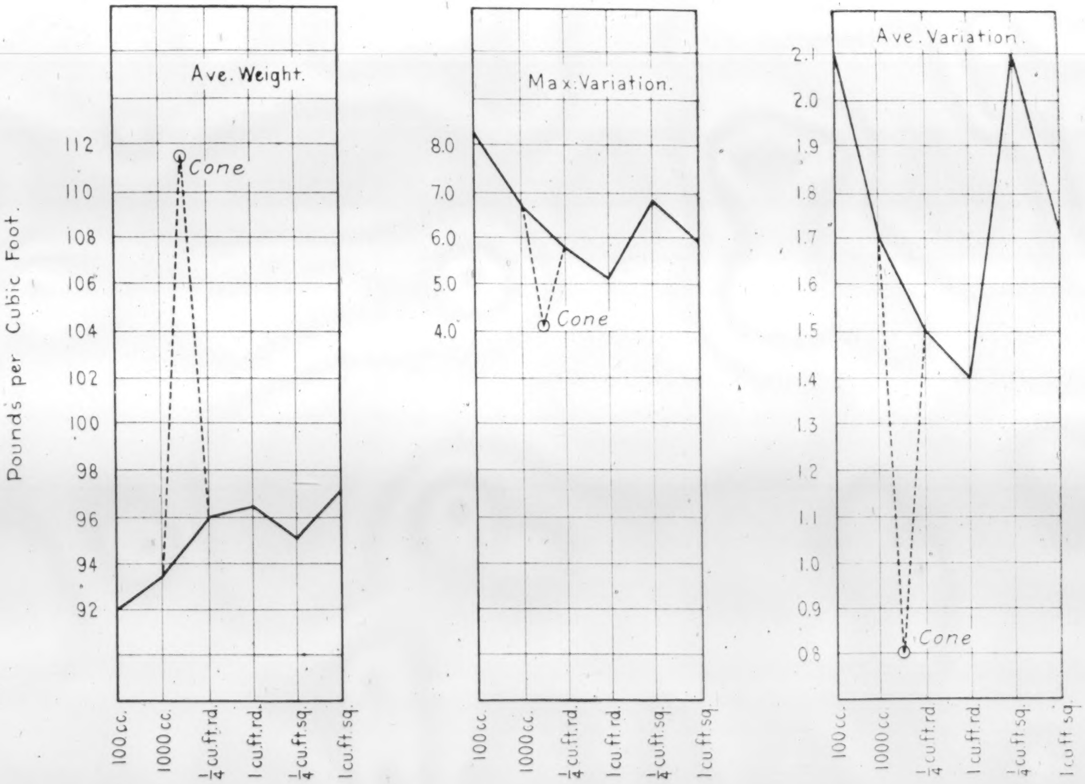
TABLE XIV AND CURVES XIV.

Table XIV is derived from Tables III, VII and XI by taking Section C from each of those tables and combining them in this table.

These data and the curves XIV show the effect of the size and shape of the measure used upon the average weight per cubic foot, upon the maximum variation or difference between



Curves XIII.—Showing Effect of Method of Filling on Average Weight, on Maximum Variation, and on Average Variation from Mean Weight.



Curves XIV.—Showing Effect of Size of Measure on Average Weight, on Maximum Variation, and on Average Variation from Mean Weight.

highest and lowest weight in each laboratory, and upon the average variation from the mean.

In the matter of average weight, it should be noted that the largest measures give the highest weights, except that the Cone Method which was used with only one size of measure gives much higher results than any other measure.

As regards maximum variation, the smallest measures give the greatest range in results, while the cubical measures give a greater range in results than cylindrical measures of equal capacity. The Cone Method having been used in one size only cannot be averaged into a diagram showing the effect of varying the size of the measure and is only indicated in this diagram as a matter of interest. It gives the smallest range in results.

TABLE XIII.—EFFECT OF METHOD ON AVERAGE WEIGHT, AVERAGE VARIATION FROM MEAN WEIGHT, AND DIFFERENCE BETWEEN HIGHEST AND LOWEST WEIGHTS OF ALL LABORATORIES, FOR ALL RESULTS.

All units in pounds per cubic foot.

Sand.	Method.								
	A	B	C	D	E	F	G	H	Core
Average Weight	88.4	98.8	103.2	104.3	98.0	83.9	87.2	95.8	111.6
" Maximum Variation	7.0	7.0	7.9	5.3	6.5	6.3	5.8	5.4	4.1
" Variation	1.9	2.1	2.2	1.4	1.7	1.7	1.6	1.0	0.8

TABLE XIV.—EFFECT OF MEASURE ON AVERAGE WEIGHT, AVERAGE VARIATION FROM MEAN WEIGHT, AND DIFFERENCE BETWEEN HIGHEST AND LOWEST WEIGHTS OF ALL LABORATORIES, FOR ALL RESULTS.

All units in pounds per cubic foot.

Sand.	Measure.						
	100 cc.	1000 cc.	$\frac{1}{5}$ cu. ft. Cone	$\frac{1}{4}$ cu. ft. Round	1 cu. ft. Round	$\frac{1}{4}$ cu. ft. Square	1 cu. ft. Square
Average Weight	92.0	93.4	111.6	96.0	96.5	95.1	97.3
" Maximum Variation	8.2	6.7	4.1	5.8	5.1	6.8	5.9
" Variation	2.1	1.7	0.8	1.5	1.4	2.1	1.7

The average variation from the mean is least in the case of the large cylindrical measures and is practically the same for both the $\frac{1}{4}$ and the 1-cu. ft. sizes.

CONCLUSIONS AND RECOMMENDATIONS.

A careful consideration of the data herein presented leads to the conclusion that Method H—the Rod Method—offers the most useful and satisfactory method of determining unit weight of concrete aggregate. Some of the objections to the other methods are:

1. The Cone Method, while giving concordant results, also gives such high values for the unit weights that the result is not of practical utility in the field. Aggregates are not measured or used in the extremely compacted condition in which they are placed in the Cone Method.

2. Method D which, with Method H, gives the most concordant results of all methods except the Cone Method, also gives high values of the unit weight, and this method gives noticeably higher average variation than Method H, as is indicated by Curves XIII.

3. All other methods investigated gave less concordant results than those just mentioned.

Method H gives a medium unit weight: one which can properly be used in proportioning concrete mixtures, as the aggregate is of about the same degree of compactness when weighed by Method H as it is in the concrete mixtures. A Unit Weight determined by this method is therefore of much greater usefulness than one determined by the Cone Method. Method H is equally well adapted to coarse or fine aggregate.

In view of these and other advantages of Method H, such as simplicity of apparatus required, etc., the sub-committee recommends the presentation to the Society of this method for publication as a Tentative Standard for the Determination of Unit Weight of Aggregate for Cement Concrete.

The sub-committee also recommends for presentation to the Society for publication as a Tentative Standard, a Method for Determining Voids in Fine Aggregate for Cement Concrete.

The recommended proposed tentative methods are appended hereto.[1]

Respectfully submitted on behalf of the sub-committee,

CLOYD M. CHAPMAN,
Chairman.

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[1] See p. 652.—ED.

REPORT OF COMMITTEE C-11
ON
GYPSUM.

Committee C-11 has held two meetings during the past year.

In spite of the business stress existing during the year, the work of the committee has been carried on with an unusual degree of industry and enthusiasm. As a result of this work, the committee is now prepared to make the following statements and recommendations to the Society:

Tentative Specifications for Gypsum.—The committee has adopted a number of revisions of the Tentative Specifications for Gypsum (C 22 – 19 T)[1] submitted with its last annual report. These revisions are so numerous and in such detail that the committee has rewritten the specifications and appended[2] them to its report in their proposed revised form. The most important revisions are briefly as follows:

> The definition for *Broken* gypsum, Section 2 (*b*), has been changed to include but one instead of the three grades specified under Nos. 1, 2, and 3. The revised matter is found under *Crushed* gypsum, Section 3 (*b*) of the revised specifications.
>
> The omission of Nos. 1, 2, and 3 grades for *Broken* gypsum, resulted in the grades following, viz., Nos. 4, 5, and 6 for *Ground* gypsum, being changed to Nos. 3, 2, and 1, as shown in Section 3 (*c*) of the revised specifications.
>
> The specifications for *Ground* gypsum, Section 2 (*c*), have been changed so that for ground gypsum of grade Nos. 5 and 6, all of the material shall pass a 14-mesh instead of an 8-mesh sieve. Slight changes have also been made in the percentage of material (for grades Nos. 5 and 6) passing through a 100-mesh sieve. The revised matter is found under Section 3 (*c*) of the revised specifications.
>
> Section 6 has been replaced by a section which specifies that the chemical composition shall be a matter of contract. It appears as Section 7 of the revised specifications.

---

[1] *Proceedings*, Am. Soc. Test. Mats. Vol. XIX, Part I, p. 575 (1919).

[2] See p. 609.—Ed

In Section 7, the words "shipped for resale" have been added and the statement "Failure to meet this guarantee will constitute a basis for rejection" has been omitted. The revised matter is found under Section 8 of the revised specifications.

Section 12, relating to "Rejection" of material, has been reworded to require reference to the "specific cause of failure." Also, the time for reporting such is changed from "five" to "ten" working days. The revised matter is found under Section 11 of the revised specifications.

Section 13, relating to "Rehearing", has been changed to require claims to be "made" instead of "filed." The time limit has been placed at "twenty" instead of "five" working days. The revised matter is found under Section 12 of the revised specifications.

The committee recommends that these revisions be accepted and the specifications as thus revised continued as tentative. The letter ballot vote of the committee on this recommendation is as follows: Affirmative, 21; negative, 1; not voting, 5.

Tentative Specifications for Calcined Gypsum.—The committee has also adopted a number of revisions of the Tentative Specifications for Calcined Gypsum (C 23 - 19 T).[1] As in the case of the specifications for gypsum, the revisions proposed are so extensive that the specifications have been revised and are appended hereto[2] in their proposed form. The principal revisions in the specifications are briefly as follows:

In definition for Calcined gypsum, Section 1, the words "incomplete or complete" have been omitted. The revised matter is found under Section 2 of the revised specifications.

In Section 2, relating to Classes A, AA and AAA for Calcined gypsum reference to the percentage of $CaSO_4 \cdot \frac{1}{2}H_2O$ if partially or totally dehydrated has been omitted, as also the terms "raw" and "rock". The revised matter is found under Section 3 of the revised specifications.

Section 4 has been replaced by a section which specifies that the chemical composition shall be a matter of contract. It appears as Section 7 of the revised specifications.

---

[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XIX, Part I, p. 578 (1919).

[2] See p. 612.—ED.

The grades of "Fineness" listed as Nos. 5 and 6 in Section 6, have been changed to Nos. 2 and 1. Grade No. 4 has been omitted. The percentages passing through a 100-mesh sieve have been slightly changed in the case of grades Nos. 5 and 6, and in No. 6 the first screen has been changed from a 28 to a 14-mesh sieve. The revised matter is found under Section 4 of the revised specifications.

Specifications for "Yield", Section 7, have been omitted.

The "Tensile Strength", Section 8, has been changed from 100 lb. per sq. in. to 200 lb. per sq. in. The word "Partially" and the sentence "all classes, when mixed with water to form a paste of normal consistency which is then molded into briquettes and allowed to set until dry" have been omitted. The revised matter is found under Section 12 of the revised specifications.

Section 9, relating to the "Compressive Strength", has been similarly changed in wording. The required strength remains unchanged. The revised matter is found under Section 13 of the revised specifications.

Section 13, relating to "Packing and Marking", has been changed to provide for shipment in bulk. Also, instead of requiring data relative to the "Class of Material" on the tag, a "Description" is deemed sufficient. The revised matter is found under Section 20 of the revised specifications.

Section 15, relating to "Rejection", has been changed so as to require reference to the "specific cause" for such. The revised matter is found under Section 22 of the revised specifications.

In Section 16, relating to "Rehearing", the words "specific cause for" have been added and the time period changed from "five" to "twenty" working days. The revised matter is found under Section 23 of the revised specifications.

The following sections have been revised and have been transferred to these tentative specifications from the Tentative Report on Gypsum Plasters (Vol. XIX, Part 1, 1919):

Sections 14, Fineness, 15 Color, 16 Plasticity, 17 Time of Setting, 18 Tensile Strength, 19 Compressive Strength

The committee recommends that these revisions be accepted and the specifications as thus revised continued as tentative. The letter ballot vote of the committee on this recommendation is as follows: Affirmative, 21; negative, 1; not voting, 5.

Tentative Methods for Tests of Gypsum and Gypsum Products.—The committee has also adopted a number of revisions of the Tentative Methods for Tests of Gypsum and Gypsum Products (C 26 – 19 T).[1] As in the case of the two preceding specifications, the revisions proposed are so extensive that the methods have been revised and are appended hereto[2] in their proposed revised form. The principal revisions in the methods are briefly as follows:

> In Section 1, the temperature of drying has been changed from 60 to 45° C.
>
> In Section 2, "Fineness", the size of screen has been changed from "$\frac{1}{4}$-in." to a "No. 3" screen.
>
> In Section 6, relating to the determination of "Silica", the "10 cc." of water has been changed to "25 cc." In transferring the precipitates the words "papers containing the" have been added, and the section amplified as to method of operation and drying temperature.
>
> In Section 9, relating to the determination of "Magnesia", the 2-per-cent washing solution has been changed to 2.5-per-cent.
>
> In Section 12, paragraph (*e*), relating to the "Calculation of Results" with reference to reporting results, the term "and report as percentages of impurities" has been changed to read "and report in the aggregate." Also, in paragraph (*l*) relating to the percentage of water, the word "combined" has been added so as to refer to "combined water." Also, in paragraph (*m*) relating to $CaSO_4$ present, the reading has been changed to refer to the "percentage of $CaSO_4$." Also, in paragraph (*n*) relating to the determination of $CaSO_4$ by a microscopic examination, the word "may" has been used instead of "should."
>
> Section 15, which defines "Plaster of Paris", has been changed to define "Calcined Gypsum."

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XIX, Part I, p. 613 (1919).

[2] See p. 634.—ED.

In Section 19, dealing with "Precautions for Physical Tests", paragraph (*d*), referring to the use of retarder has been entirely omitted.

A footnote has been added to Sub-title VI to the effect that specifications for normal consistency of sanded mixtures will be supplied by the committee when the information is available.

Section 22, relating to the determination of normal consistency by means of Southard Viscosimeter, has been reworded and the field method appearing as a footnote has been included in the form of a note following the laboratory method.

Section 23. Water Carrying Capacity has been reworded.

Section 24. Determination of Dry Bulk has been reworded. Instead of an average of "five" tests, an average of "three" has been adopted. Dry Bulk is expressed in cubic centimeters per 100 grams instead of grams per 100 cc.

Section 25, relating to the Determination of Wet Bulk, has been reworded and the "note" following has been omitted.

Section 26, relating to the Determination of the Time of Setting has been reworded and a method for such determination has been given.

Section 27, Determination of Tensile Strength, has been reworded to provide better and more uniform drying. The variation of 10 per cent has been changed to 15 per cent.

The following additional matter has been supplied by the Committee:

Section 28. Determination of Compressive Strength.

Section 26. Determination of Time of Setting.

The committee recommends that these revisions be accepted and the methods as thus revised continued as tentative. The letter ballot vote of the committee on this recommendation is as follows: Affirmative, 20; negative, 0; not voting, 7.

The sub-committee in charge of these methods is now engaged in revising the method for determining free water in gypsum and in developing methods for the measurement of plasticity and of color.

Specifications for Gypsum Plasters.—During the year the Executive Committee decided that those portions of the committee's 1919 report on gypsum plasters relating to considerations of application, workmanship and erection were not "indispensable in specifications designed to cover the customary relations between the producers and consumers of a given product",[1] and that, therefore, these considerations should not be included in Specifications for Gypsum Plasters. The committee has cheerfully acquiesced to this ruling, and has reorganized its work in accordance therewith. In doing so, the committee desires, however, to call the attention of the Society to the fact that this question of gypsum plaster is probably as close to the limit of the jurisdiction of the Society as any case which can probably arise. The committee feels justified, therefore, in reserving the right to bring this matter up for further consideration, in case the Society should at any future time decide to extend its jurisdiction.

The report last year discussed gypsum plaster under the following headings: Materials and Standards; Bases or Backgrounds; Grounds; Application; and General Precautions. As a result of the ruling of the Executive Committee, all of the previous report under the last four headings has been eliminated. The committee has also revised the specifications submitted last year under the heading "Materials and Standards" and appends hereto revised Specifications for Gypsum Plasters with the recommendation that they be accepted by the Society for publication as tentative. The letter ballot vote upon this recommendation is as follows: Affirmative, 20; negative, 1; not voting, 6.

The sub-committee having the above specifications in charge is now developing specifications for sand for use with gypsum.

The 1919 report on the design of reinforced gypsum beams has also been ruled to be beyond the jurisdiction of the Society. The sub-committee on structural gypsum has therefore abandoned its efforts in this direction and is now developing specifications for gypsum block, plaster board and wall board.

Mr. A. H. Apted has been appointed by Committee C-11 to represent it on the new Standing Committee on Nomenclature, the organization of which has been authorized by the Executive Committee. He will bring before the new committee the Tentative Definitions of Terms Relating to the Gypsum Industry (C 11 - 16 T).[1] Until such time as the Committee on Nomenclature has acted, Committee C-11 recommends that these definitions be continued as tentative.

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[1] This quotation is from Section 14 of the Regulations Governing Standing Committees. See 1919 Membership List, p. 321.—ED.

This report has been submitted to letter ballot of the committee which consists of 27 members, of whom 21 have voted affirmatively, 1 negatively, and 5 have refrained from voting.

Respectfully submitted on behalf of the committee,

WARREN E. EMLEY,
Chairman.

V. G. MARANI,
Secretary.

EDITORIAL NOTE.

The proposed revisions of the Tentative Specifications for Gypsum, the Tentative Specifications for Calcined Gypsum, and the Tentative Methods for Tests of Gypsum and Gypsum Products, referred to in this report, were accepted. The specifications and methods as thus revised were continued as tentative and appear on pages 609, 612 and 634 respectively.

The proposed Tentative Specifications for Gypsum Plasters were accepted for publication as tentative and appear on pages 616–619.

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[1] See p. 658.

REPORT OF COMMITTEE D-1
ON
PRESERVATIVE COATINGS FOR STRUCTURAL MATERIALS.

Committee D-1 on Preservative Coatings for Structural Materials, which now has 108 members, has held two meetings since the last annual meeting of the Society. At the meeting held in Philadelphia on November 22, 1919, 34 members were present; at the meeting held in Philadelphia on March 27, 1920, 41 members were present.

During the last year valuable cooperative work was carried out on certain paint vehicles under the auspices of Sub-Committee III on Testing of Paint Vehicles. A sample of pure tung oil, expressed from imported nuts, was reported in 1914.[1] This sample was kept for a period of about six years in a black bottle, and this year was reexamined in a number of laboratories. It was found that the appearance of the oil had altered somewhat, as the oil was white and very turbid instead of being clear. The so-called constants of this sample, such as specific gravity, iodine number, etc., were determined and compared with the values reported for this oil in 1914. No material change in these constants was found and hence it is very probable that the white and turbid condition of the oil has been caused through isomeric change of the elaeomargaric glyceride rather than by polymerization of the oil.

In connection with the work on tung oil, the committee has tried out an improvement of the Browne Heat Test, which in the cooperative work gave excellent results. It will be noted in this connection that samples of commercial tung oil, supposed to be pure, gave different results from the above mentioned oil expressed in this country in 1914 from imported nuts, the results naturally leading one to suspect that all imported tung oil contains some foreign oils. The good results obtained by the modified heat test have led the committee to propose a revision[2] of the present Standard Specifications for Purity of Raw Tung Oil (Serial Designation: D 12 - 16),[1] giving the new heat test and omitting the iodine jelly test now included in the specifications.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XIV, Part I, p. 237 (1914).

[2] See p. 819.

The committee has also conducted cooperative work on two methods of making a Hexabromide Test for linseed oil. Results obtained by the Steele-Washburn method, as applied by six operators, are very good and indicate that this method may prove of great value in determining the adulteration of linseed oil with such oils as soya bean oil. The details of this work will be found in the report of Sub-Committee III.

While no further investigations on turpentine have been undertaken by Committee D-1 during the past year, Sub-Committee XII on Turpentine has considered a Government specification and is recommending a revision of the Standard Specifications for Turpentine (Serial Designation: D 13 - 15)[1] to be in conformity with the specifications recommended by the Government Interdepartmental Committee on Paint Specification Standardization.

While no formal reports are submitted by the other sub-committees, it may be stated that several of these sub-committees have done considerable work. Sub-Committee VI on Definitions of Terms Used in Paint Specifications has prepared and issued to Committee D-1 a number of definitions for discussion, and it is hoped that definite recommendations regarding some of these definitions may be made during the next year.

Sub-Committee XI on Paint Thinners other than Turpentine has also been active and has prepared specifications for certain paint thinners to be circulated in the committee, but this work was not completed at an early enough date to justify any recommendations at this time.

At the meeting in Philadelphia on March 27, the present Sub-Committee XV on Specifications for Pigments Dry and in Oil when Marketed in that Form was discharged and another sub-committee was appointed to consider the adoption of specifications for pigments in conformity with those issued by the Government Interdepartmental Committee on Paint Specification Standardization.

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[1] 1918 Book of A.S.T.M. Standards.

A newly organized Sub-Committee on Specifications for the Fundamental Requirements of Paint for Specific Purposes, while it makes no formal report, has been instrumental in having presented to the Society several papers for the annual meeting.

This report has been submitted to letter ballot of the committee which consists of 108 members; 54 ballots were cast.

The vote was taken on each section of the report. Following is the result of the ballot:

	Affirmative.	Negative.	Not Voting.
General Report	50	0	4
Report of Sub-Committee III, including revision of the Specification for Tung Oil	49	0	5
Report of Sub-Committee XII, including revision of the Specification for Turpentine	47	2	5

Respectfully submitted on behalf of the committee,

P. H. Walker,
Chairman.

G. W. Thompson,
Secretary.

Editorial Note.

The proposed revision of the Standard Specifications for Purity of Raw Tung Oil was accepted for publication as tentative and appears on pages 819–821.

The proposed revised Specifications for Turpentine were accepted for publication as tentative and appear on pages 680–689.

REPORT OF SUB-COMMITTEE III ON TESTING OF PAINT VEHICLES.

TESTS OF TUNG OIL.

The subject of the heat test in the present Standard Specifications for the Purity of Raw Tung Oil (D 12 - 16)[1] has received much consideration during the past year. At the suggestion of members of the committee, the apparatus has been slightly modified. For tests with the modified apparatus there was forwarded to each member of the committee samples of oil as follows:

100 per cent Pure A.S.T.M. Tung Oil.
95 per cent Pure A.S.T.M. Tung Oil— 5 per cent Soya Bean Oil.
90 per cent Pure A.S.T.M. Tung Oil—10 per cent Soya Bean Oil.
85 per cent Pure A.S.T.M. Tung Oil—15 per cent Soya Bean Oil.

No. 1 J. G. Commercial Tung Oil 100 per cent.
No. 2 J. G. Commercial Tung Oil 90 per cent—Soya Bean Oil 10 per cent.

No. 1 A. A. Commercial Tung Oil 100 per cent.
No. 2 A. A. Commercial Tung Oil 90 per cent—Soya Bean Oil 10 per cent.

The oil referred to above as pure A.S.T.M. Tung Oil was of the same batch reported in the Proceedings for 1914.[2] This oil was pressed at the Bureau of Chemistry from Chinese tung-oil nuts delivered by the agricultural explorer of the Bureau of Plant Industry; the nuts having been imported from China by L. C. Gillespie and Co., New York City. This oil had been kept for a period of six years in a black bottle at the Bureau of Chemistry and the Bureau of Standards. It had been opened on only one occasion, about a year ago, at which time it was perfectly clear and fluid. A small sample was then withdrawn. The container was again sealed and kept for a further period of one year, at which time the bottle was opened to obtain samples for the present work. It was then noted that the oil was turbid. Upon placing a vessel containing a sample of the oil in warm water, the oil would immediately clear up.

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[1] 1918 Book of A.S.T.M. Standards.

[2] *Proceedings*, Am. Soc. Test. Mats., Vol. XIV, Part I, p. 237 (1914).

The soya bean oil used was a commercially pure sample previously used in committee work. The sample of J. G. Commercial Tung Oil was recently obtained from one of the largest tung-oil producers in America, who stated that the oil was of the usual high-grade quality. The sample of A. A. Commercial Tung Oil used was recently obtained from one of the largest oilcloth firms in America from a lot that had proved very satisfactory, and which in their opinion represented the highest grade tung oil commercially obtainable.

TABLE I.—CONSTANTS OF VARIOUS OILS USED IN 1920 TESTS—REPORT BY BUREAU OF STANDARDS.

Properties.	Linseed Oil.	Soya Bean Oil.	Pure A.S.T.M. Tung Oil No. 2, 1914.	No. 1 A.A. Commercial Tung Oil.	No 1 J.G. Commercial Tung Oil.
Specific Gravity at 15°.6/15°.6 C.......	0.9314	0.9297	0.9406	0.9393	0.9404
Acid Number	4.6	10.75	1.3	4.4	4.8
Saponification Number................	191.5	194.2	192.4	193.6	193.2
Iodine No. (Hanus 25 cc., ½ hour)......	178.7	135.8	....	....	....
Iodine No. (Hübl 18 hours)..........	....	....	170.4	170.0	170.6
Iodine No. (Wij ½ hour room temperature)	....	....	163.4	161.1	163.1

It is very interesting to compare the constants obtained for the 1914 A.S.T M. No. 2 Pure Tung Oil with the results reported by the committee in 1914.

Properties.	Tung Oil No. 2, 1914 Analysis.	Tung Oil No. 2, 1920 Analysis.
Specific Gravity at 15°.5/15°.5 C................................	0.9396	0.9406
Acid Number	0.90	1.3
Saponification Number....................................	193.02	192.4
Iodine Number (Hübl 18 hours)............................	169.6	170.4

The Browne heat tests on this oil as conducted in 1914 correspond closely to those obtained in 1920.

Taking in account the limit of accuracy of the determinations, the analysis of this tung oil after an interval of six years seems to show that it is unchanged, with the possible exception that the sample has increased to a very slight degree in acid number.

The conclusion to be drawn from these results is that the formation of white solid material evident in the sample after the storage in a black bottle for six years is not due to polymerization, but to an isomeric change in the elaeostearic glyceride molecule.

There is given in Table I a report of the Bureau of Standards on the analytical constants of these oils. The linseed oil referred to was used in the Hexabromide tests reported separately. It was obtained from a tank-car shipment known to be pure.

The instructions sent out to the sub-committee for work on these oils is presented below:

> The illustration (Fig. 1)[1] depicts the type of improved apparatus to be used by the members of Sub-Committee III in testing the pure and adulterated samples of tung oil recently forwarded for cooperative work. The method of running the test is essentially that given below (Browne method). It should be noted however that a glass cup 11 cm. in diameter is recommended. It should also be noted that two test tubes are inserted. One tube contains a known or control sample of pure or satisfactory oil as a standard by which to judge the value of any sample that may be placed in the other tube. An iron or wood cover plate is used. A Tagliabue thermometer according to the following specification is used:
>
> > Chemical thermometer, engraved stem; total length 4 to $4\frac{1}{2}$ in.; graduated from 210 to 310° C. in intervals of 2° C.; the interval 210 to 310° C. to be not less than $2\frac{1}{2}$ in. long; bulb to be made of good grade thermometer glass; to be well annealed. Thermometer to be nitrogen-filled.
>
> The method of procedure is given below. By this method the polymerization period for the pure control sample of tung oil may for instance run 10 minutes. Every additional 5 per cent of adulteration may increase the time of setting approximately $1\frac{1}{4}$ minutes.
>
> *Heating Test Procedure.*[2]—Test tubes for containing the oil should be 15 cm. by 16 mm., with a mark near the bottom to indicate 5 cc., and closed by a cork so perforated that a glass rod 3 mm. in diameter can move freely.
>
> In the experiments the thermometer is placed so as to be 1.5 cm. from the bottom of the bath. In ascertaining the temperature of the bath, due attention is given to the cool column of the mercury, so that corrected temperatures are recorded.
>
> "When the bath temperature is 293° C. (560° F.) and very slowly rising at this point, the tube containing 5 cc. of the oil to be tested is fixed in so that the bottom of the tube is level with the lowest part of the bulb of the thermometer. The time is noted, and the source of heat removed for about 45 seconds and then reapplied. Before 2 minutes have elapsed the temperature of the bath will have fallen to 282° C. (540° F.), at which point it should be kept as steady as possible. When the tung oil has been in the bath about 9 minutes, the glass rod is raised at intervals of $\frac{1}{2}$

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[1] See p. 821.

[2] Quoted from *Proceedings*, Am. Soc. Test. Mats., Vol. XIV, Part I, p. 242 (1914).

minute, and when the rod is firmly set the time is again noted.[1] As setting or jellying takes place within a few seconds of fluidity, a good end determination is afforded. The specimen is at once removed, the bath is again heated to 293° C., and the experiment is repeated with another portion of the sample. There is no difficulty in obtaining results which do not differ by more than $\frac{1}{2}$ minute. No stirrer is used in the bath. A screen around the bath enables the temperature to be more easily reached. When the cottonseed oil has become tarry and viscid, it should be renewed; otherwise heating may be irregular. The jelly may be removed by half filling the tubes with strong sulfuric acid and placing in a warm place a few hours."

TABLE II.—HEAT TEST ON TUNG OILS.

Oils.	Gardner and Reily.	Bailey Baldsiefen and Whitescarver.	Kohr, McFadden, Fasig and Marling.	Pickard.	S. and P. Waldstein.	White and Crowley.	Steele.	Lindsay and Ross.	Maximum.	Minimum.	**Average.**
100 per cent Pure American Pressed A.S.T.M. Tung Oil	$9\frac{1}{4}$	$9\frac{1}{2}$	$9\frac{1}{4}$	$9\frac{1}{2}$	$9\frac{3}{4}$	$9\frac{1}{12}$	$9\frac{1}{2}$	$9\frac{1}{4}$	$9\frac{3}{4}$	$9\frac{1}{4}$	$9\frac{1}{2}$
95 per cent Pure American Pressed A.S.T.M. Tung Oil 5 per cent Soya Bean Oil	$10\frac{1}{2}$	$10\frac{1}{4}$	$9\frac{5}{6}$	$10\frac{1}{4}$	11	$10\frac{1}{4}$	$11\frac{1}{4}$	$10\frac{1}{4}$	$11\frac{1}{4}$	$9\frac{5}{6}$	$10\frac{3}{8}$
90 per cent Pure American Pressed A.S.T.M. Tung Oil 10 per cent Soya Bean Oil	$11\frac{1}{2}$	$11\frac{1}{8}$	$11\frac{1}{2}$	$11\frac{3}{4}$	$12\frac{1}{4}$	$11\frac{1}{2}$	$12\frac{1}{4}$	$11\frac{1}{2}$	$12\frac{1}{4}$	$11\frac{1}{8}$	$11\frac{3}{4}$
85 per cent Pure American Pressed A.S.T.M. Tung Oil 15 per cent Soya Bean Oil	$13\frac{1}{4}$	$13\frac{1}{4}$	$12\frac{5}{6}$	13	$13\frac{1}{4}$	$12\frac{5}{6}$	14	$13\frac{1}{4}$	14	$12\frac{5}{6}$	$13\frac{1}{8}$
100 per cent J. G. Commercial Tung Oil	$11\frac{3}{4}$	$12\frac{3}{8}$	....	12	12	$11\frac{1}{2}$	$11\frac{1}{4}$	11	$12\frac{3}{8}$	11	$11\frac{3}{4}$
90 per cent J. G. Commercial Tung Oil 10 per cent Soya Bean Oil	14	$14\frac{3}{8}$	....	14	14	$13\frac{3}{4}$	$14\frac{1}{2}$	$13\frac{1}{4}$	$14\frac{1}{2}$	$13\frac{1}{4}$	14
100 per cent AA Commercial Tung Oil	12	$12\frac{3}{8}$	....	$12\frac{1}{2}$	$12\frac{1}{4}$	12	$12\frac{3}{4}$	$11\frac{3}{4}$	$12\frac{3}{4}$	$11\frac{3}{4}$	$12\frac{1}{3}$
90 per cent AA Commercial Tung Oil 10 per cent Soya Bean Oil	$14\frac{1}{2}$	$14\frac{5}{8}$	....	$14\frac{3}{4}$	$14\frac{3}{4}$	$14\frac{1}{6}$	$14\frac{3}{4}$	$13\frac{3}{4}$	$14\frac{3}{4}$	$13\frac{3}{4}$	$14\frac{1}{2}$

The reports sent in by the various observers are presented in Table II.

With the reports that were sent in comments were included by various observers. These are digested below:

In the work by White and Crowley the results shown represent the work of at least three check determinations on each sample.

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[1] If apparatus is used with wire gauze support for tubes in place of *C* collar support the end point is noted when oil stiffens so that entire tube may be lifted through opening by aid of the glass rod. (See results of Lindsay and Ross.)

S. and P. Waldstein noted that the pure A.S.T.M. tung oil when received was in a cloudy and semi-solid condition. When heated it became clear, but subsequently reverted to its original condition on recooling. This caused them to wonder whether this condition was the natural one for absolutely pure tung oil. They commented upon the fact that the pure American Pressed A.S.T.M. tung oil bodied in approximately 9 minutes whereas all commercial samples received in paint and varnish factories give a heat test of not less than 11 minutes. They approve of the glass beaker which was substituted for the copper beaker as enabling the operator to observe the temperature more closely.

Kohr, McFadden, Fasig and Marling make brief comment on the condition and viscosity of the first four samples.

Bailey, Baldsiefen and Whitescarver suggest that in laboratory work a number of determinations be run on a pure oil and the average gelatinizing time determined. When an unknown oil is tested the standard should be run at the same time and in the same bath. The gelatinizing time of the unknown oil is represented by the observed time plus or minus the same correction which it is necessary to make to the observed gelatinizing time of the standard to correct it to the "average gelatinizing time" as previously determined.

Lindsay and Ross find it very inconvenient to use a rubber stopper for holding the test tubes in the plate, stating that the stopper becomes soft and spongy and does not hold the tubes in place. They found a cork stopper preferable. They also state that they believe the method might be greatly improved by taking as the end point that point at which it is possible to lift by means of the rod the entire test tube through the opening at *C*. For this determination it will be necessary to do away with the rubber stoppers *C* in the plate openings for the tubes. As supports for the tubes to keep them 15 cm. from the bottom of the beaker, they recommend the use of a table placed in the oil bath and made of a small bent wire screen. The rods within the tubes are placed in corks having sufficiently large openings so that the rods move freely.

Conclusions.—Through the use of the Browne Heat Test as revised, more concordant results are shown in the hands of the various operators than appear in the work done with the original test in 1914–1915.

It is further apparent that by this revised method tung oil containing as low as 5 per cent soya bean oil can be differentiated from pure tung oil. The use of this test with revisions noted is therefore recommended to the paint and varnish industry for the examination of tung oil.

It would further appear from the results of the heat test run by the committee from 1914 to date, that most of the imported commercial tung oils contain appreciable quantities of other oils. In order to determine whether this conclusion is justified, the committee has arranged through different sources to obtain absolutely pure tung oil expressed in China under responsible supervision. Samples thus obtained will be used during the coming year in cooperative work.

It is recommended that the committee be instructed to propose a revision of the present Standard Specifications for Purity of Raw Tung Oil (Chinese wood oil) (D 12 - 16)[1] substituting the modified Browne Heat Test for the Heat Test as now issued. It is also recommended that the Iodine Jelly Test be omitted until further work is done thereon. These proposed revisions are embodied in the Appendix to this report.

WORK ON HEXABROMIDE VALUES OF LINSEED OIL.

A new method of determining the hexabromide value of linseed oil having been worked out by Dr. Steele and Mr. Washburn[2] of the Bureau of Standards, and a modification of this method by Mr. Bailey, it was the desire of the sub-committee to determine their value and whether fairly close checks might be obtained with these methods when followed by various operators. Accordingly, samples of the following oils were sent out to the sub-committee for this work:

Linseed Oil	100 per cent
Linseed Oil	85 "
Soya Bean Oil	15 "
Linseed Oil	75 "
Soya Bean Oil	25 "
Linseed Oil	65 "
Soya Bean Oil	35 "

The linseed oil and soya bean oil used are described in Table I. Copy of the instructions sent to the sub-committee together with the methods by Steele and by Bailey are given below:

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[1] 1918 Book of A.S.T.M. Standards.

[2] *Journal of Industrial and Engineering Chemistry*, Vol. 12, p. 52, January, 1920.

Information has often been requested as to the best method of determining the purity of raw soya bean oil and the purity of raw linseed oil. The iodine numbers of these oils are not always the indices of their purity. Similarly because of the fact that raw linseed oil from North American seed may often have an iodine number as high as 185 while raw linseed oil from South American seed may have an iodine number as low as 170, it has been suggested that there would be difficulty in determining whether oil having an iodine number of approximately 170 was obtained from South American seed or really compounded by mixing North American linseed oil with smaller amounts of soya bean oil. Since the ordinarily used methods of chemical analysis would not differentiate between certain mixtures, it has been the desire of the analytical chemist to use some other method of identification. It would appear that such means are now available with special Hexabromide Tests. These tests measure the percentage of ether-insoluble brominated products yielded by the oil in question. Raw linseed oil, for instance, has a hexabromide number of approximately 46, whereas soya bean oil has a hexabromide number of usually less than 5.

In order to determine the usefulness of the hexabromide method, the writer, as chairman of Sub-Committee III on Testing of Paint Vehicles, has forwarded to members of the sub-committee samples of pure linseed oil and pure linseed oil mixed with varying amounts of soya bean oil. The cooperative analytical work that is being done on these oils should give information of great interest. The committee will cooperate with Sub-Committee V on Linseed Oil.

There is attached herewith the two methods (Steele and Washburn and Bailey's modification thereof) by which the hexabromide test may be made. The Bailey modification differs from the Steele and Washburn method in that an acetic acid-bromide solution is used instead of a chloroform-bromide solution. The Bailey modification also entirely eliminates the use of chloroform from the reaction mixture and does not require "amyline" or other reagent for removing the excess of bromide after the bromination of the fatty acids. The Bailey modification, however, requires the precipitated hexabromides to first stand over night in an ice chest instead of immediate washing.

A NEW HEXABROMIDE TEST FOR LINSEED OIL.

BY L. L. STEELE AND F. M. WASHBURN,

Bureau of Standards.

A. *Preparation of Reagents.*

The following reagents are necessary:

1. *Chloroform.*—Shake ordinary U. S. P. chloroform with several portions of water to wash out all the alcohol. Dry the product with granulated anhydrous calcium chloride over night in order to remove all traces of water.

Decant from the calcium chloride and distill. Add to the distillate 3 cc. of absolute ethyl alcohol for every 100 cc. of chloroform. Keep in a stoppered brown bottle.

2. *Bromide Solution.*—Mix one part by volume of C. P. bromine[1] with two parts by volume of chloroform, prepared as above. This solution must be made up fresh each day because it deteriorates upon standing.

3. *Wash Ether.*—Shake ordinary ethyl ether with 10 per cent of its volume of ice-cold distilled water. Separate and repeat the washing three times. Dry the washed ether with fused calcium chloride over night. Decant the ether through a folded filter into another flask and add thin slices of sodium. Warm gently on a steam bath under a reflux condenser until the evolution of gas by action of the sodium has practically ceased and bits of freshly cut sodium remain bright in the ether. Distill the ether into a dry bottle and add an excess (at least three grams per liter) of finely powdered hexabromide of the fatty acids of linseed oil previously prepared. If no hexabromide is on hand from previous determinations it may be easily prepared as follows: In a centrifuge tube dissolve about 5 g. of the fatty acids of linseed oil in 15 to 20 cc. of chloroform. Place the tube in a freezing mixture and add slowly, with shaking, bromine solution until a slight red color is permanent. Add a few drops of amylene to take up excess of bromine. Whirl in a centrifuge until the precipitate has settled and then pour off the chloroform. Rub up the precipitate with 20 cc. of cold absolute ether, whirl in a centrifuge and pour off the wash ether. Repeat the washing with three more 20 cc. portions of ether. After drying, the hexabromide is pure enough for the preparation of wash ether. Shake at intervals for 2 or 3 hours or allow the mixture to stand over night. Then place the bottle in ice water so that the ether solution will be at zero or not above 2° C. for three hours. Decant the ether solution rapidly through a folded filter into a dry bottle and keep tightly corked in order to prevent loss of ether by evaporation.

4. *Amylene.*—This material may be purchased from the Eastman Kodak Co. It is one of the organic chemicals prepared in the laboratory of the University of Illinois. It may be prepared in small quantities from amyl alcohol by the method of Adams.[2]

B. Preparation of the Fatty Acids.

Weigh approximately 50 g. of linseed oil into a 1½-liter Florence flask, and add 40 cc. NaOH solution (sp. gr. 1.4) and 40 cc. of alcohol. Place the mixture on a steam bath and heat for about ½ hour. Add 1 liter of hot distilled water and insert into the neck of the flask a 2-hole rubber stopper carrying a tube which projects into the flask so that its end is slightly above the liquid, and pass a stream of CO_2 through the tube into the flask. The soap mixture may then be heated, to remove the alcohol, either over a free flame or on the steam bath. If the free flame is used, a capillary "boiler" must be placed in the liquid, since otherwise the soap solution will bump badly. If excessive foaming takes place, the current of CO_2 should be increased until it is strong enough to break up the foam. If the solution is heated on the steam bath, usually about 2 to 3 hours is required to remove the alcohol, while if it is boiled over a free flame, ½ hour is usually sufficient. After the alcohol has been removed, cool the soap solution and acidify with dilute HCl (1 : 1). Insert a 3-hole rubber stopper, carrying two glass tubes arranged as for a wash bottle, leaving the third hole in the stopper open for an outlet for the CO_2. The inlet tube should extend to just above the layer of fatty acids, and the outlet tube should extend to the bottom of the flask. It is essential that the outlet tube should not extend down more than an inch or two outside of the flask, as otherwise siphoning would take place, causing the liquid to boil inside the tube.

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[1] The authors have observed that samples of bromine marked "C. P." often contain considerable amounts of non-volatile material. All bromine which is used must be redistilled unless it is found that 5 g. leave no weighable residue upon evaporation.

[2] *Journal*, Am. Chem. Soc., 1918, p. 1950.

Pass a stream of CO_2 through the system and boil gently, using a capillary boiler to prevent bumping, until the layer of fatty acids is clear. Plug the hole in the stopper which acts as an outlet for the CO_2. The lower layer will be forced out through the outlet tube by the pressure of the CO_2. In this manner remove as much water as possible without losing any of the fatty acids, then remove the stopper and add about 500 cc. of hot distilled water, shake thoroughly so that the fatty acids are well washed, allow the fatty acids to separate and siphon off the wash water as before. Repeat the washing until the wash water does not give an acid reaction with methyl orange. Before removing the last washing, insert a capillary boiler and boil gently until the fatty acid layer is clear. After the last washing, remove the stopper and suck up with a pipette the last few globules of water. Filter the hot fatty acids through a folded filter under an evacuated bell jar and keep in a well stoppered bottle.

C. Preparation of Hexabromides.

Weigh accurately in a weighed centrifuge tube (approximately 6½ in. long by 1 in. in diameter) 1.00 g. (plus or minus 0.05 g.) of linseed fatty acids, prepared as given above. Dissolve in 10 cc. of chloroform and place the tube in a freezing mixture kept as near −5° C. as possible, made by adding a little dilute HCl to finely cracked ice. Add bromine solution from a burette at the rate of one or two drops per second, shaking the tube well during the addition. At first the bromine color will be rapidly discharged, but later the mixture will assume a permanent orange color indicating a slight excess of bromine. For most fatty acids of linseed oil about 1 cc. of the bromine solution will be found necessary to give the orange color. At this point run in rapidly 0.5 cc. more of the bromine solution, shake well, and allow the tube to stand in the ice mixture for 10 minutes. Remove the tube from the freezing bath and add amylene drop by drop with shaking until the bromine color has entirely disappeared. Usually five to six drops of amylene are sufficient, but a slight excess does no harm. The addition of bromine solution must never be done in direct sunlight.

Attach the tube to a good water vacuum pump (one which will indicate a pressure not greater than 40 mm. of mercury) by means of a new one-hole rubber stopper. Evaporate the chloroform in a vacuum, warming the tube in water at 50 to 60° C. to hasten evaporation. The tube must be constantly shaken to prevent bumping of the chloroform. Towards the end of the evaporation, when the contents of the tube become more viscous, rotate and tilt the tube so that the oil will flow about half way up the sides and thus present more surface for evaporation. When practically all the chloroform has been evaporated, place the tube in a bath at 55 to 60° C. for 15 minutes, keeping the suction on.

Detach from the pump and place the tube in a bath of finely cracked ice and water. When the tube is cold pour down its sides 20 cc. of cold wash ether, as prepared above. The wash ether should have been previously placed in four corked test tubes graduated at 20 cc. by a file mark and kept at 0° C. in an ice bath. Thoroughly stir and rub up the bromide mixture with a rod, breaking up all the lumps. Return the tube to the ice bath for 2 minutes and then whirl in a centrifuge until the precipitate has settled into a hard cake and the supernatant liquid is clear. Return the tube to the ice bath for 2 minutes and then pour off the wash ether, making sure that no solid material is lost. Repeat the washing of the hexabromide precipitate three times in exactly the same way, using three 20 cc. portions of ice-cold wash ether and rubbing up the precipitate thoroughly each time. Use a weighed stirring rod and wash the precipitate adhering to the rod into the tube with the wash ether at each washing of the hexabromide. Afterwards dry and weigh the rod plus the slight coating of precipitate and add the weight of material on the rod to the weight of the main portion of hexabromide. After the fourth ether washing has been poured off, carefully incline and tap the tube and spread the hexabromide precipitate part way up the sides. Warm the tube in water at 50 to 60° C. until most of the ether has evaporated. Attach to the suction pump and place the tube in a bath at 60 to 70° C. for 15 minutes. Detach the tube from the pump, cool in cold water to room temperature, wipe dry with a towel and weigh at once. Dry the tube to constant weight in an oven at 100–110° C. The total weight of the precipitate times 100 divided by the weight of fatty acids taken, gives the hexabromide percentage. The hexabromide should dry pure white.

D. Special Precautions:

1. Have the chloroform dry and adjust its alcohol content to 3 per cent.

2. Make sure that all the chloroform is evaporated from the impure hexabromide before adding wash ether. This will be accomplished if the water pump indicates a pressure not greater than 30–40 mm. and the tube is heated in the bath at 60° C. for two-thirds of its length.

3. Make sure that the wash ether is anhydrous and free from alcohol and that it is saturated with hexabromide at 0° C. Unless the wash ether is allowed to stand at 0° C. for a sufficient length of time before filtering off excess hexabromide, it will be super-saturated at 0° C. and will give high results. Care should be taken to prevent appreciable loss of ether by evap-

oration; it is well to cool the stock bottle of wash ether on hot days before uncorking.

4. Make sure that the centrifuge tube containing the hexabromide and the wash ether are kept as near 0° C. as possible during the process of washing. The finely cracked ice should be replenished at intervals.

5. It has been found that low and non-concordant hexabromide results on pure linseed oil by the new method can nearly always be traced to the use of a faulty vacuum pump or to faulty rubber connections. Therefore, the operator should convince himself by test with a mercury manometer immediately before making the determination that his pump, as used, will give a vacuum of not greater than 30 mm. mercury. Heavy walled pressure tubing should always be used for connections. A faulty pump or faulty rubber connections usually means that the chloroform is not all evaporated from the impure hexabromide and will exert a solvent action on the hexabromide later on, thus giving low yields.

6. If a Nelson rotary oil pump is available, it is an excellent plan to remove the last traces of chloroform by attaching the centrifuge tube to this type of pump for 15 minutes. The bulk of the solvent should be removed first by means of the water pump.

7. With either pump the tube should be heated in a bath of 60–65° C., during the evaporation of the last traces of chloroform.

BAILEY'S MODIFICATION OF STEELE AND WASHBURN METHOD.

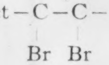
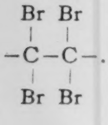
HEXABROMIDE NUMBER.

References.

The literature on the determination of hexabromide numbers is not very extensive. The following are the recent references of value:

"Chem. Tech. and Anal. of Oils, Fats & Waxes," by Lewkowitsch, 5th Ed., Vol. I, p. 568.
Farben Zeitung (1912) No. 3 ff.
Muggenthaler, Inaug. Dissert. 1912, Augsburg.
Bailey and Johnson, J. I. E. C. *10*, 999.

Principle.

The unsaturated fatty acids when treated under proper conditions with bromine absorb at each unsaturated linkage two or more atoms of bromine depending on the degree of unsaturation. Thus at a double bond $-C=C-$ there is obtained a saturated bromo product  $-\underset{Br}{\underset{|}{C}}-\underset{Br}{\underset{|}{C}}-$ and at a triple bond $-C=C-$ four bromine atoms are absorbed to give a saturated compound  $-\overset{Br}{\overset{|}{\underset{Br}{\underset{|}{C}}}}-\overset{Br}{\overset{|}{\underset{Br}{\underset{|}{C}}}}-$. The solubility in ether of the bromo derivatives decreases rapidly with increase of bromine content. Thus the di and tetra bromo compounds are easily soluble, whereas the hexa (and octo) compounds are only very sparingly soluble. This fact is made use of to separate the hexa (and octo) bromo derivatives in carrying out the analytical determination.

Status.

The following method is applicable to the determination of the hexabromide number of saponifiable oils. It must be remembered that the hexabromide number depends upon the method employed in making the determination. It is, therefore, important that in reporting results, the particular method must be specified.

Reagents and Apparatus.

(*a*) *Reagents:*

(1) C. P. sodium hydroxide solution of 1.4 sp. gr.
(2) 95-per-cent alcohol.
(3) Distilled water.
(4) C. P. hydrochloric acid.
(5) CO_2 or nitrogen.
(6) C. P. bromine containing no non-volatile matter.
(7) Glacial acetic acid showing no reduction with dichromate or permanganate in the usual test.
(8) Wash ether:

Shake ordinary ethyl ether with 10 per cent of its volume of ice-cold distilled water. Separate the water and repeat the washing three times. Dry the washed ether with fused calcium chloride over night. Decant the ether through a folded filter into another flask and add thin slices of sodium. Warm gently on a steam bath under a reflux condenser until the evolution of gas by action of the sodium has practically ceased and bits of freshly cut sodium remain bright in the ether. Distill the ether into a dry bottle and add an excess (at least 3 g. per liter) of finely powdered hexabromide of the fatty acids of linseed oil previously prepared. (If no hexabromide is on hand from previous determinations, it may be prepared as follows: In a centrifuge tube dissolve about 5 g. of the fatty acids of linseed oil in 25 cc. of ether. Place the tube in a freezing mixture and add slowly with shaking bromine solution until a red color is permanent. Let stand for at least 15 minutes and then whirl the tube in a centrifuge until the precipitate has settled and then pour off the ether. Rub up the precipitate with 20 cc. of cold absolute ether, whirl in a centrifuge and pour off the wash ether. Repeat the washing with 3 more 20-cc. portions of ether. After drying, the hexabromide so obtained is pure enough for the preparation of the wash ether.) Shake at intervals for 2 or 3 hours or allow the mixture to stand over night. Then place the bottle in ice water so that the ether solution will be at zero or not above 2° C. for at least three hours. Decant the ether solution rapidly through a folded filter into a dry bottle and keep tightly corked in order to prevent the loss of ether by evaporation.

(*b*) *Apparatus:*

(1) Steam bath.
(2) Gas burner.
(3) Iron tripod, ring stand and wire gauze.
(4) Round bottom flask of 2 liters capacity.
(5) Separatory funnel, 500 cc.
(6) Bell jar.
(7) Well annealed test tubes 5 by 1 in.
(8) 50-cc. burette.
(9) Glass stirring rods 6 by $\frac{3}{16}$ in.
(10) Glass battery jars.
(11) Graduated cylinders 10 and 50 cc. capacity.
(12) Small pipettes about 3 cc. capacity for weighing out samples.
(13) Centrifuge giving about 3000 r. p. m.
(14) A vacuum showing no higher than 40 mm. pressure.

Determination.

(*a*) *Preparation of Fatty Acids.*—Weigh approximately 50 g. of oil into a 2-liter round-bottom flask and add 40 cc. of NaOH solution (sp. gr. 1.4 = 36.50-per-cent sol.) and 40 cc. of alcohol. Place the mixture on a steam bath and insert a 2-hole rubber stopper into the neck of the flask carrying a tube which projects into the flask so that its end is just above the liquid. Heat for about one-half hour, passing a stream of CO_2 through the apparatus all the while. Add one liter of hot distilled water and boil the soap solution to remove the alcohol, either over a free flame or on a steam bath. If a free flame is used about one-half hour's boiling will be sufficient, but it may be necessary to insert capillary tubes to prevent bumping of the liquid. If the solution is heated on the steam bath, usually 2 to 3 hours are required. After removing the alcohol, the solution is cooled somewhat and then acidified with dilute HCl (1 : 1). Warm the mixture until the fatty acids form a clear layer, continuing to pass CO_2 through the system all the time. The fatty acids are separated from the aqueous layer by means of a 500-cc. separatory funnel. The funnel is filled with the mixture, and the fatty acids will float on top, and the aqueous portion is run off. The remainder of the mixture in the flask is added to the funnel and the aqueous portion again run off. A brisk stream of CO_2 is passed into the funnel to replace the air; 300 cc of hot distilled water is added and the mixture is vigorously shaken. After the fatty acids collect on top the aqueous portion is run off. This washing is repeated until the water is neutral to methyl orange, three washings usually being sufficient. The warm fatty acids are run into a centrifuge tube (1 by 5 in.) and whirled for about one minute to collect any remaining water at the bottom. They are then filtered by decantation on to a folded filter under an evacuated bell jar and kept in a well-stoppered bottle.

(*b*) *Preparation of the Hexabromides.*—Weigh accurately in a weighed centrifuge tube (1 in. diameter by 5 in. long) as nearly as possible 1 g. of fatty acids. It was found that in the case of linseed oil better results are obtained by keeping the weight of the sample as near to 1 g. as possible, so the deviations from this should not be more than ±0.02 g. Dissolve the fatty acids in 25 cc. of the specially prepared ether and place the tube in a freezing mixture kept at about −5° C. made by adding a little HCl to finely cracked ice. Add bromine solution[1] from a burette at the rate of about one or two drops per second, shaking the tube well during the addition until a deep red color is produced. This should not be done in direct sunlight. The tube is then allowed to stand in an ice chest over night (about 14 hours), the proper precautions being taken to prevent the loss of solvent by evaporation by inserting a stopper.

It is necessary to let the tube stand for this period of time because in the case of oils which contain only a small amount of linolenic acid (soya bean oil is a good example) the precipitation of the hexabromide proceeds more slowly than in the case of an oil with a larger content of linolenic acid (linseed for example).

Next morning cool the tube by immersion in a bath of cracked ice and rub up the precipitate by means of a weighed glass rod, being sure to loosen any material adhering to the side of the tube. Whirl the tube in a centrifuge till the precipitate forms a hard cake on the bottom, cool in the ice bath, and decant the ether. Add 20 cc. of the wash ether previously prepared and cooled to 0° C. and rub up the precipitate with the glass rod. Return the tube to the ice bath and when cold whirl it in the centrifuge. Return the tube to the ice bath and then remove the ether by decantation. Repeat this washing twice more. After the last washing incline the tube and carefully tap it to spread the hexabromide precipitate part of the way up the sides. Warm the tube in water at 60° C. until most of the ether has evaporated, then attach it for 15 minutes to a vacuum line showing a pressure of 30–40 mm. keeping the temperature around 60° C. Wipe the tube dry and allow it to stand in the balance at least 15 minutes before weighing. To the weight of the precipitate in the tube add the weight of the slight amount adhering to the glass rod. This total weight of precipitate multiplied by 100 and divided by the weight of fatty acids taken, gives the hexabromide percentage.

Notes:

1. The fatty acids are used instead of the glyceryl esters because the latter give inconcordant results.
2. In the case of linseed oil, the weight of the sample should be kept as near 1 g. as possible.
3. Care should be exercised in preparing the wash ether for if it is unsaturated with hexabromides according to directions, the results will be low.

The results of the various observers are given in Table III.

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[1] 5 cc. bromine, 25 cc. glacial acetic acid made up just before use

Comments made by the various observers are abstracted herewith:

S. and P. Waldstein state that when a large percentage of soya bean oil is present in an oil there is formed a large percentage of tetrabromide which may not be completely washed out. They recommend in such instances to increase the portions of ether to 25 or 30 cc. or to increase the number of washings to 5 or 6 in order to overcome high results.

The chairman of the sub-committee has done some experimental work with the idea of developing a method of determining the hexabromide value of oils volumetrically. It was found that the bromine absorption number of the fatty acids of linseed oil were higher than for soya bean oil in some preliminary volumetric work. It is known that the bromine substitution number of linseed oil fatty acids is low while the fatty acids of soya bean oil have a low addition number. Considerable further work, however, will be necessary in order to develop a method that will be satisfactory.

TABLE III.—HEXABROMIDE VALUES.

Oils.	Steele-Washburn Method.									Bailey Modification of Steele-Washburn Method.		
	Gardner and Bielouss.	Steele.	Came.	White and Crowley.	Bailey.	P. and J. Waldstein.	Maximum.	Minimum.	Average.	Came.	Bailey.	Average.
100 per cent Pure Raw Linseed Oil.	45.9	46.4	46.6	45.4	46.0	46.2	46.6	45.4	46.1	40.5	42.7	41.6
85 per cent Pure Raw Linseed Oil 15 per cent Soya Bean Oil......	39.3	....	41.8	39.1	41.9	39.8	41.9	39.1	40.4	34.9	37.5	36.2
75 per cent Pure Raw Linseed Oil 25 per cent Soya Bean Oil......	36.4	38.4	38.2	36.0	37.2	36.1	38.4	36.0	37.0	31.5	34.5	33.0
65 per cent Pure Raw Linseed Oil 35 per cent Soya Bean Oil......	30.8	33.4	34.8	30.5	33.8	33.5	34.8	30.5	32.8	26.7	31.4	29.6

Conclusions.—The Steele-Washburn method of determining hexabromides has given closely concordant results in the hands of several different operators, and is apparently well adapted for determining the purity of raw linseed oil. It is recommended that further work be carried on with the object of shortening the method.

Respectfully submitted on behalf of the sub-committee,

HENRY A. GARDNER,
Chairman.

REPORT OF SUB-COMMITTEE XII ON TURPENTINE.

No further investigation of turpentine has been conducted by Sub-Committee XII during the past year. The U. S. Interdepartmental Committee representing a number of the Federal Departments has prepared specifications for turpentine which are in the main similar to the specifications of this Society[1] but which are, in some respects, an improvement over those specifications particularly as relates to methods of testing.

These Interdepartmental specifications have been considered by the sub-committee and it is recommended, in order that there may be only one recognized set of specifications for turpentine, that the Interdepartmental specifications for turpentine be adopted by the Society. These specifications are appended hereto,[2] and if approved by the Society, should be published as tentative for one year.

Respectfully submitted on behalf of the sub-committee,

F. P. VEITCH,
Chairman.

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[1] Standard Specifications for Turpentine (Serial Designation: D 13 - 15), 1918 Book of A.S.T.M. Standards.

[2] See p. 680.—ED.

REPORT OF COMMITTEE D-2
ON
LUBRICANTS.

Committee D-2 presents herewith[1] a revision of the Tentative Test for Viscosity of Lubricants (D 47 - 19 T)[2] with the recommendation that it be referred to letter ballot of the Society for adoption as standard. The changes made in the tentative test are as follows:

(*a*) The bath, and means for controlling temperature of the bath, have been omitted from the figure and the description of the apparatus. The form of bath and heating devices illustrated in the Tentative Test are not essential to the proper carrying out of the test. Any suitable bath and heating means may be employed which give the necessary temperature control.

(*b*) Certain slight changes in phraseology have been made which do not alter the method of test or the results obtained.

Reports of Sub-Committees III on Sulfur Determination and Differentiation and V on Emulsification are appended.

This report and the tentative test recommended for adoption as standard have been submitted to letter ballot of the committee which consists of 32 members; 30 ballots were returned, and 2 members refrained from voting:

	Affirmative.	Negative.	Not Voting
General Report	27	1	2
Standard Test for Viscosity of Lubricants	27	1	2

Respectfully submitted on behalf of the committee,

C. P. Van Gundy,
Chairman.

K. G. Mackenzie,
Secretary.

Editorial Note.

The proposed revision of the Tentative Test for Viscosity of Lubricants was accepted. The test, as thus revised, was approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1920, and appears in the supplementary pamphlet of A.S.T.M. Standards Adopted in 1920.

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[1] This test as revised is not reprinted here but appears in the supplementary pamphlet of A.S.T.M. Standards adopted in 1920

[2] *Proceedings*, Am. Soc. Test. Mats., Vol. XIX, Part I, p. 728 (1919).

REPORT OF SUB-COMMITTEE III ON SULFUR DETERMINATION.

Sub-Committee III of Committee D-2 is charged with the problem of presenting methods for the determination and differentiation of sulfur. Three selected samples of oils in which sulfur was present in different combinations were sent to the members of the sub-committee, with the request that they actually determine the percentage of sulfur by any one or more methods with which they were familiar. Of these samples, one was a mixture of topped Mexican petroleum, thinned out with 300 fire test illuminating oil and filter strained; the second, a 300 oil to which flowers of sulfur had been added and then heated to a temperature at which the sulfur went into solution, the so-called vulcanizing temperature; and third, a commercial heavy red oil which was a product of the destructive distillation of a naphthene crude, acid treated, neutralized with soda and blown bright. Because of insufficient washing, sulfur was present as sulfonates. The impression gained from the reports sent in is that we can profitably concentrate on a very few methods. Authorities agree that sulfur shall be determined by first converting it into sulfuric acid, then precipitating with barium chloride, and weighing the precipitate as barium sulfate. The method devised by Carius of sealing a portion of the fuel with fuming nitric acid in a glass tube, and heating under the pressure developed to complete oxidation, may perhaps be considered the standard, but there are others which give so nearly identical results without the difficulties incident to carrying out that experiment that the selection of one of them as an arbitration method appears justifiable. Combustion in a bomb has enough points in its favor to merit its consideration as the approved method. While various bomb calorimeters are now in use in many laboratories, it was thought at least one other method involving less expensive apparatus might be recognized. Dry fusion with Eschka's and other alkaline mixtures has been extensively used, but the results reported on the samples have been so variant that it seems desirable to change the earlier suggestion of recommending it as alternative. However, suitable Eschka reagents are now obtainable from supply houses, the test can be carried out with crucibles found in every laboratory, and it is probable this method will continue to be used in directive tests.

QUANTITATIVE METHODS USED.

In the hands of its inventor and his colleagues, Dr. Conradson's method gives results comparable with bomb combustions, but in reporting his figures, Dr. Conradson writes: "As you know, my method was essentially developed for the purpose of taking sulfur in burning oils and refined lubricating oils, which of course contain much less sulfur than the sample you submitted. For the determination of sulfur contents of oils like the sample you sent (topped Mexican) it would seem to me that the bomb method would be the one to use."

The method proposed by Rothe, detailed in Holde's "Examination of Hydrocarbon Oils," gave such good results, and because this and Dr. Waters' method require so little apparatus, they are both being given in full. Rothe' method is as follows:

> "Three to four grams of oil with 1.5 g. of magnesium oxide and 30 to 40 cc. of nitric acid (sp. gr. 1.48) are placed in an 800 to 1000-cc. round bottom Jena flask, in a hood. After the first violent reaction, the flask is heated gently for 1.5 to 2 hours on a sand bath, the liquid being kept boiling gently. The excess nitric acid is then evaporated over a free flame and the residue heated till the nitrates begin to decompose. After cooling, 10 cc. concentrated acid are again added. After fifteen minutes heating, the mass is evaporated to dryness, keeping the flask in constant motion, then heated with a triple burner until the nitrates are completely decomposed. The residue is generally white; by adding 10 cc. of hydrochloric acid (sp. gr. 1.124) and heating, it is dissolved and then filtered after diluting with 20 to 30 cc. of water. In the filtrate, the sulfuric acid is determined by precipitation with barium chloride in the customary manner."

This method has been used for the analysis of vulcanized rubber, and Dr. Waters calls attention to a report made in 1917 in *Communications*, Delft Rubber Institute, Part V, p. 144, in which it is stated that in compounds containing 7.5 per cent sulfur, some of which is uncombined, "duplicate results are to be expected to differ by 0.2 to 0.3 per cent of sulfur, and that they may even differ by 0.5 per cent." As a percentage inaccuracy on an element so difficult to estimate, this is not excessive, but is given to show the conclusion reached by experienced operators, as well as to indicate the accuracy of this method. One of the objections raised against it by members of the committee may be largely overcome by the use of an 800 to 1000-cc. flask instead of the 250-cc. flask recommended in Holde.

Following is the method proposed by Dr. C. E. Waters, who allowed it to be used by the sub-committee before publication:

DETERMINATION OF SULFUR IN LUBRICATING OILS
BUREAU OF STANDARDS.

The method described below has been found to give very concordant results with various lubricating oils, with topped Mexican crude, both alone and when mixed with mineral seal, and with a vulcanized 300 oil which contained hydrogen sulfide and probably also free sulfur. It is possible that the method will be useful for lighter oils.

Weigh from 0.5 to 1.5 g. of oil into a porcelain crucible of 100-cc. capacity, add 5 cc. of concentrated nitric acid saturated with bromine and at once cover the crucible with a watchglass. If there is danger of losing sulfur, as with a vulcanized oil, each sample should be treated with acid as soon as it is weighed out. Place on the steam-bath, but not directly in contact with the steam, and digest for 30 minutes or more with an occasional gentle swirling of the crucible so as to mix the oil and acid. If the mixture in the crucible does not threaten to foam up to the watchglass, the crucible is now to be heated directly by the steam for two or three hours. If the mixture foams up too high, the crucible should be left where it was first placed.

Remove the crucible from the steam-bath, and when its contents are cold, raise the watchglass slightly and add cautiously, in small portions 10 or 12 g. of anhydrous sodium carbonate. This is conveniently measured in a 15-cc. crucible, rather than weighed. The first portions of soda usually remain on the top of the oily layer, so that the crucible must be tilted or swirled slightly to start the reaction. When a little more than half of the soda has been added it is safe to rinse the watchglass with 1 or 2 cc. of water. Add the remaining soda and then with a stout glass rod (3 mm. thick) about 10 cm. long, thoroughly mix the contents of the crucible. The resulting pasty mass is spread around the sides of the crucible and one-half to two-thirds of the way to the top. If the right amount of water is added, the mass will adhere to the sides of the crucible. The rod is left in the crucible. Dry on the steam-bath or in an air-bath at about 100° C., place the crucible in an inclined position on a wire triangle and start the ignition over a low flame. When more than a gram of oil has been taken, there is a slight tendency for it to burn a little too briskly but this is controllable by judicious use of the stirring rod, which scrapes the burning portion away from the rest. When part of the mass is burned white a fresh portion is worked into it, and so on until all of the organic matter is destroyed. It is usually necessary to hold the edge of the crucible with tongs. Towards the last half of the operation the flame should be increased somewhat, but it is never necessary to heat the crucible to redness. With care, a crucible can be used for at least 10 or 12 determinations.

According to the amount of oil taken, the mixture of sodium salts resulting from the combustion varies from pasty to granular. After cooling, the crucible is placed on its side in a 400-cc. beaker containing about 150 cc. of water. Cover the beaker and digest on the steam-bath. When the salts have dissolved rinse out the crucible and filter the solution to remove specks of carbon, chips from the glass rod, etc. Acidify with concentrated hydrochloric acid, using Congo red paper as indicator, and add about 1 cc. of acid in excess. The reaction proceeds more safely if nearly the required amount of acid is placed in a covered beaker and the solution filtered directly into it. The total quantity of carbonate and nitrate to be neutralized will depend upon the amount of oil taken. Heat on the steam-bath, add 10 cc. of 10-per-cent barium chloride solution and digest until the solution clears. If time permits, the barium sulfate should be allowed to stand over night before it is filtered off.

A blank should be run with the reagents. In doing this it is necessary to make an ignition as if oil were present, because the flame may contain some sulfur. In testing reagents recently used, only a trace of barium sulfate was formed when the ignition was not made; with that included, the correction amounted to 0.03 per cent of sulfur, calculated on one gram of oil. Most of this barium sulfate came down over night.

A simple gasoline gas generator, to avoid the danger of sulfur contamination of illuminating gas, was described by Dr. Waters in the *Journal of Industrial and Engineering Chemistry*, Vol. 5, October, 1913. A gas-washing bottle, containing a layer of glass beads to break up the air-bubbles, or even a wide-mouthed bottle containing a layer of glass beads with a good cork and two glass tubes, one of which extends to the bottom of the layer of beads, can be used. Petroleum ether works very satisfactorily, especially after it has become somewhat chilled by evaporation. At first the flame is smoky but this is no great drawback, because at the start of the ignition it should be so low as not to touch the crucible.

It is evident that by the new method a considerable number of determinations can be started and completed at the same time. Individual attention is needed only during the actual combustion, which takes from 15 to 25 minutes. With a few modifications the method is the same as that devised for the determination of total sulfur in rubber goods.[1] The following figures, taken at random, show how closely results can be expected to check:

0.61	0.56	0.38	0.80	1.36	4.11
0.63	0.55	0.44	0.81	1.41	4.08
	0.56	0.42		1.36	4.11
	0.57			1.35	4.10
				1.37	4.08

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[1] Bureau of Standards, *Scientific Paper No. 174*, and *Journal of Industrial and Engineering Chemistry*, Vol. 3, October, 1911; also Bureau of Standards *Technologic Paper No. 45*, May, 1915.

One of the objections to this method is the occlusion of other salts in the barium sulfate. Knowing this tendency, however, it is a simple matter to make allowance for it. Another is that it requires too much attention. To offset the latter is the fact that it is possible to run a number of determinations at the same time.

From the observations of users of the calorimeter bombs that the odor of sulfur was noticeable on opening the bombs after ignition, it would appear that there is a possibility that not the full quantity of the sulfur was absorbed in the liquid or that the bomb was opened too soon.

Objection has been raised against the bombs having gold or platinum linings in that there is a possible chance for loss of the gases between the lining and the bomb and also that most bombs are costly. The new Parr sulfur bomb is exempt from both these objections, and fortunately also gives consistent readings. Upward of 100 combustions have been made in one of these bombs in the laboratory under the direction of the chairman, and it is apparently as good as new. The directions for the determinations of sulfur when made independently of the calorimetric process, as given by Professor Parr, have been modified to a certain extent by both this laboratory and that of another member of the committee in a way tending both to safety and accuracy. The following is taken almost entirely from the report submitted by Dr. Charles K. Francis:

> The charge may consist of from 0.3 to 0.5 g. delivered from a weighing bottle equipped with a dropping tube. One gram of accelerator (potassium chlorate) is weighed into the bomb. then 0.2 g. of benzoic acid. The oil is next weighed in and mixed well with the chemicals by means of a glass stirring rod. A full measure of sodium peroxide is added, the bomb closed with a false cap, and the entire charge thoroughly mixed by shaking. In the case of very viscous oils, it may be necessary to stir a part of the sodium peroxide in with the glass rod. (*Special precaution.*—Do not forget to add the sodium peroxide. A mixture of accelerator and oil alone when heated is likely to burn with explosive violence.) Ignite the charge by applying the flame of a Bunsen burner to the bottom of the fusion cup. Remove the flame as soon as the reaction has commenced, which will be indicated by the lower portion of the cup becoming a dull red. If the apparatus is supported in the flame by taking hold of the short stem of the cover with crucible tongs, the point of ignition of the charge is shown by a slight kick which will be felt by the hand holding the tongs. After the charge has ignited, the bomb may be cooled without delay by holding under the tap or submerging in water. If the cover is

fitted with a rubber gasket, the cooling with water should follow very soon after ignition. The fusion is removed by the aid of hot water. The solution is neutralized with chemically-pure hydrochloric acid added slightly in excess and filtered. Barium chloride (10 cc. of a 10-per-cent solution) is added to the boiling solution which is then allowed to stand in a warm place over night, is filtered, washed, ignited and weighed as barium sulfate. As a precaution it is well to run a blank at the same time.

IDENTIFICATION AND QUALITATIVE TESTS.

The Renshaw method for determining the presence of sulfonates has been criticized, but in the hands of those who have used it for a number of determinations, it has at least been found helpful. The apparatus and reagents of performing this test are as follows: Nickel crucible, Caustic potash, c. p., Sulfuric acid, c. p., concentrated, Potassium iodate free from iodide (1 per-cent solution), Starch paste. Fuse 15 to 20 cc. of oil with about 2 g. caustic potash in the nickel crucible. Shake up with 25 to 30 cc. distilled water in the crucible, boil and filter. To filtrate add 1 cc. starch-paste, 1 cc. iodate solution and a few drops sulfuric acid. Appearance of a blue color indicates the presence of SO_3. One operator reported: "the addition of acid caused effervescence. When the alkalinity of the solution was nearly neutralized, a faint blue color was observed which disappeared upon shaking. The addition of one more drop of acid caused the formation of a permanent blue color. On addition of more acid, this color disappeared".

Does not this indicate that the blue color is due to some coloring matter which disappears in the acid solution, and that by a close observation when nearing the neutral point the blue can be discerned? The same operator raises the question as to whether or not this test may indicate sulfur in any form, basing the question on examination of a Mexican crude and a manufactured oil, the latter containing 2.25 per cent sulfur.

It is believed that Dr. Herschel's demulsibility test, Dr. Conradson's steam test, and Dr. Delbridge's recently proposed R E test, indicate the presence of sulfonic acids, and these are perhaps well enough understood so that one or the other may eventually become the test for sulfur in the form of sulfonates.

The presence of native sulfur or of that element in such combination as to be injurious to copper can be detected by half immersing strips of polished copper ½ in. wide by 3 in. long in oil contained in test tubes, stoppered and stood in a warm place over night. The presence of injurious sulfur is shown by very apparent discoloration of the copper under the oil.

When bringing the results of all the analyses together, it was apparent that some of them were so inaccurate as to warrant their not figuring in the totals. Just why these inaccuracies occurred, it is difficult to tell, but from the fact that the same operator reported two or more determinations close enough together to be good checks, it would look as though there were either some loss of a gas or possibly impurities in chemicals. The figures given in the following table are all considered worthy of reporting. It will be seen that the determinations under the Eschka method are all so low as to justify our conclusions that it can be used only as a qualitative determination. Whether the greater variations on the topped Mexican are due to the larger percentage of sulfur or to the condition in which the sulfur exists, or to both, it is difficult to say.

Topped Mexican Crude.

Bomb Method.		Eschka's Method.	
Low	1.68	Low	1.10
High	1.983	High	1.74
Average (10 determinations)	1.803	Average (4 determinations)	1.33
Parr (Oxygen), average	1.72		
Atwater-Mahler, average	1.963		
Parr (Sodium Peroxide), average	1.784		

Conradson's Lamp Method.		Waters' Method.	
Low	1.68	Low	1.30
High	1.68	High	1.85
Average (2 determinations)	1.68	Average (7 determinations)	1.64
		Average (3 determinations)	1.826

Rothe's Method.	
One determination	1.76

Average of 22 determinations (omitting Eschka figures) 1.74

Vulcanized Oil.

Bomb Method.		Eschka's Method (2 + 1).	
Low	1.122	Low	0.95
High	1.252	High	1.19
Average (13 determinations)	1.191	Average (10 determinations)	1.05
Average (5 determinations)	1.18		

Parr (Oxygen), average	1.02		
Emerson, average	1.18		
Atwater-Mahler, average	1.25		
Parr (Sodium Peroxide), average	1.18		
Eschka's Method, Modified (4 + 1).		Conradson's Method.	
Low	1.05	Low	1.13
High	1.13	High	1.16
Average (2 determinations)	1.09	Average (4 determinations)	1.14
Waters' Method.		Rothe Method.	
Low	0.94	Low	1.57
High	1.41	High	1.81
Average (8 determinations)	1.23	Average (7 determinations)	1.72
Average (6 determinations)	1.33		

Average of 25 determinations (omitting Eschka and Rothe figures) ... 1.195

HEAVY RED OIL.

Bomb Method.		Eschka's Method (2 + 1).	
Low	0.39	Low	0.28
High	0.53	High	0.38
Average (15 determinations)	0.48	Average (6 determinations)	0.33
Parr (Oxygen), average	0.48		
Emerson, average	0.46		
Parr (Sodium Peroxide), average	0.51		
Eschka's Method, Modified (4 + 1).		Renshaw Method.	
Low	0.39	Presence of sulfonates:	
High	0.41	Yes 5	
Average (2 determinations)	0.40	No 1	
Waters' Method.			
Low			
High			
Average (9 determinations)	0.476		

Average (omitting Eschka figures) ... 0.4785

The chairman is under an obligation, which is hereby acknowledged, to the various members of the sub-committee and to his own laboratory staff for the excellent support which they have given him in the results so far accomplished. He requests helpful criticisms not only from the members of this sub-committee, but from any one interested in order that this entire topic may be reported on at the next session with recommendations for tentative methods.

Respectfully submitted on behalf of the sub-committee,

FLORUS R. BAXTER,
Chairman.

REPORT OF SUB-COMMITTEE V ON EMULSIFICATION.

This committee during the past year has investigated a new test for the determination of the tendency of an oil to emulsify or its resistance to emulsification, a test designed by the chairman and others. Appended herewith is a paper describing this test in detail and the results obtained so far.

Further work will be carried on with this test in comparison with other tests for emulsification already proposed.

Respectfully submitted on behalf of the sub-committee,

T. G. Delbridge,
Chairman.

APPENDIX

DETERMINATION OF RESISTANCE OF LUBRICATING OILS TO EMULSIFICATION.[1]

SUMMARY.

A method for determining Resistance to Emulsification (R. E.) of lubricating oils is described, embracing the following features:

1. Accurate indication of the true value of an oil in practice as far as emulsion resistance qualities are concerned, thus affording a basis for classification and for specifications of lubricating oils.
2. Reproducibility of results.
3. Practical elimination of personal factor.
4. Ease of operation.
5. Simplicity and availability of apparatus.
6. Rapidity of determination, 6 to 26 minutes being required.
7. Small quantity of oil used (20 cc.).
8. Adaptability to a wide range of lubricating oils.

INTRODUCTION.

The value of an oil for many forms of lubrication is largely dependent on its ability to resist emulsification, and to separate readily if emulsion is formed.[2] A measure of this quality is of importance. Many methods have been proposed and used with varying degrees of success; of these the most important are the tests of Messrs. Bryan,[3] Stratford,[4] Conradson[5] and Herschel.[6]

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[1] Devised in connection with work of Committee D-2 on Lubricants, American Society for Testing Materials. V. R. Abrams, Technical Engineer, Chas. H. Osmond, Physical Chemist, and T. G. Delbridge, Chief Chemist of the Atlantic Refining Co.

[2] Bibliography of emulsion tests. Bureau of Standards *Technologic Paper No. 86*, 1917.

[3] *Journal*, Am. Soc. Naval Engrs., Vol. XXVI, p. 561, 1914.

[4] Paper presented before Soc. Auto. Engrs., June, 1915.

[5] *Proceedings*, Am. Soc. Test. Mats., Vol. XVI, Part II, p. 273 (1916).

[6] *Proceedings*, Am. Soc. Test. Mats., Vol. XVI, Part II, p. 248 (1916).

NATURE OF TEST.

The method to be described is based on the emulsifying action of steam when injected into oil. The emulsion, during formation, is maintained at a definite temperature, and is surrounded by a water bath at a definite lower temperature; these conditions produce an approximately uniform rate of heat loss by conduction and therefore uniform rate of heat and steam supply, thus stabilizing conditions of emulsion formation. Separation of emulsion thus formed is maintained under uniform conditions and results are interpreted as explained later.

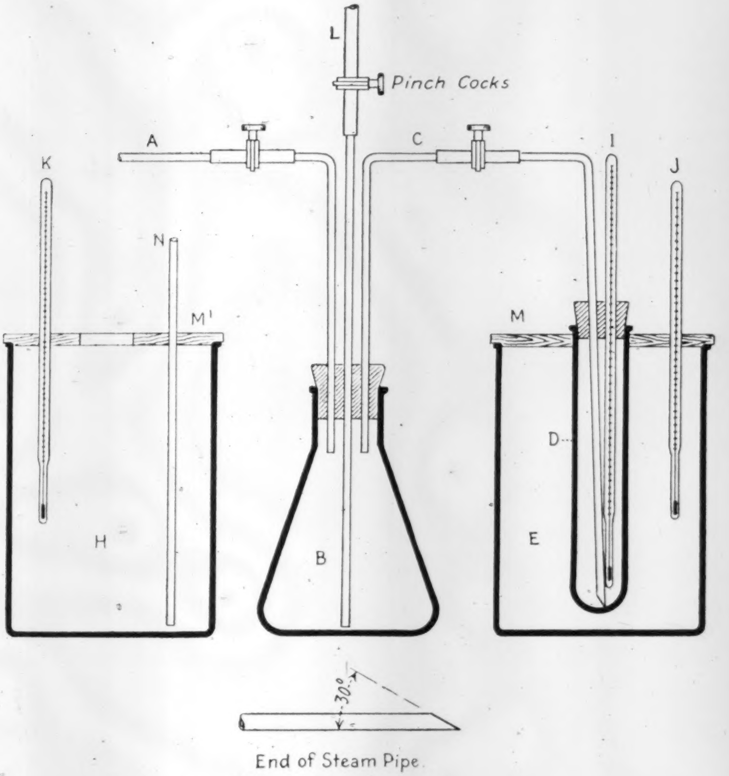

FIG. 1.—Apparatus for Test for Resistance to Emulsion. Exterior Steam Supply.

APPARATUS.

Two systems of apparatus may be used: First, exterior steam supply (Fig. 1) and second, self-generating steam supply (Fig. 2).

Exterior Steam Supply.—Fig. 1 consists of steam source *A* delivering steam through separator *B* with blow-off outlet *L*, controlled with a screw pinch cock. Steam vents through *C*, glass tubing with flexible connection and pinch cock as shown, passing loosely through cork at mouth of *D* and extending to the bottom thereof. This delivery tube is approximately 2.5 mm. in inside diameter and is cut off diagonally 30 deg. from

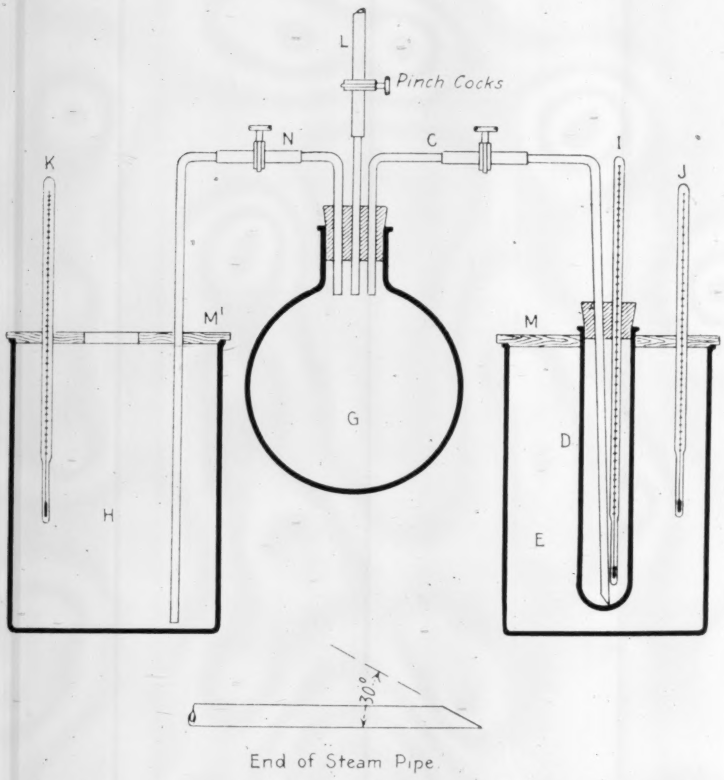

FIG. 2.—Apparatus for Test for Resistance to Emulsion. Self-Generating Steam Supply.

axis of tube at discharge orifice. Oil container *D* is a test tube 25 by 200 mm. graduated from 20 to 50 cc. in cubic centimeters. Bath *E* is a glass battery jar (3 liter capacity). (Gallon bottle with top cut off answers.) *I*, *J*, and *K* are thermometers in position as shown. Bath *H* is a glass jar similar to *E* with facilities for heating by steam or electricity. *M* and *M'* are suitable supports used as holders for test tube *D*.

Self-Generating Supply.—Fig. 2 consists of a steam generator *G*—a liter boiling flask or equivalent and necessary burner—which supplies steam in a similar manner as separator *B* as shown in Fig. 1. An additional line *N* to supply heat to the separating bath *H* may be used if desired.

METHOD OF OPERATION.

Generate or secure steam in *G* or *B*. Fill the separating bath *H* with water and raise and maintain the temperature at 200 to 203° F. Some care is required in heating up the battery jar (or bottle with top cut off) to avoid breakage. Fill emulsion bath *E* with water (3 liters ±60 cc.) and adjust the temperature to 67° F. Place 20 cc. of oil to be tested in the graduated test tube *D* at room temperature, and place test tube in holder *M* of bath *E*.

Steam out line *C* until condensation disappears.

Place cork containing the steam pipe and thermometer *I* in the test tube, with the steam pipe touching the center of the bottom of tube and the thermometer one inch from the bottom. Admit steam through the steam pipe, and control to maintain the emulsion temperature at 190 to 195° F. This control is effected by manipulation of escape valve *L*. Steam cock, line *C*, must be wide open to prevent possible sucking back. Steam supply must be sufficient to cause generous discharge at *L*. Steaming is continued until the volume in *D* is 40 cc. ±3 cc. The time required for such steaming must not be less than four minutes. If condensed water amounts to 20 cc. in less than four minutes, it indicates wet steam or incomplete steaming-out of line. The usual time required is 4.5 to 6.5 minutes, depending on the quality of oil, altitude, etc.

NOTE.—Apparent volume in tube near end of steaming operation is approximately 12 cc. greater than actual volume.

Remove the cork and attachments and transfer tube *D* and contents rapidly to the separating bath (200 to 203° F.). It is extremely important that the bath temperature be kept below 203° F. Take the time on a stopwatch on the instant of immersion and observe progress of separation through the walls of the bath. Examine every 30 seconds until 20 cc. of oil have separated. If 20 cc. of oil have not separated in 20 minutes, read the volume of separated oil at that time to the nearest $\frac{1}{2}$ cc.

INTERPRETATION OF RESULTS.

In interpreting results obtained above, assumption is made that the rate of emulsion separation is directly proportional to the Resistance to Emulsification of the tested oil. In order to establish a basis for comparison, a definite value of 100 is assigned to an oil which, under the conditions of test, separates completely from emulsion in one minute. This is equivalent to an emulsion separation rate of 0.33 cc. per second or 20 cc. per minute, and was assigned after experiments demonstrated that the results so obtained were pertinent and relative through a wide range of tests. The value assigned is denoted, "Resistance to Emulsification or R. E. value of an oil."

The Resistance to Emulsification (R. E.) of any oil may be found by substituting in the following formula:

$$\text{Resistance to Emulsification (R. E.)} = \frac{\text{number cc. separated oil} \times 5}{\text{number of minutes}}.$$

For example:

$$\text{If 20 cc. separated in 28 seconds, R. E.} = \frac{20 \times 5}{0.5} = 200$$

$$\text{If 20 cc. separated in 2.5 minutes, R. E.} = \frac{20 \times 5}{2.5} = 40$$

$$\text{If 18.5 cc. separated in 20 minutes, R. E.} = \frac{18.5 \times 5}{20} = 4.6$$

NOTE.—The expansion of the oil at higher temperature was disregarded, as the size of sample made this correction unnecessary. It will be understood that readings may be taken oftener than every 30 seconds, though this is unnecessary.

The oils which emulsified, without exception, separated into three layers: top, clear or turbid oil; middle, lacy or creamy emulsion; bottom, clear or milky water. From the top layer is derived the numerical Resistance to Emulsification (R. E. value), by comparing any results with the rate of an oil which separates at the rate of 20 cc. per minute.

The following table shows preliminary results reported by operators, inexperienced in this test, working in the laboratories which are cooperating with Committee D-2.

OPERATOR.	OIL NO. 1.	OIL NO. 2.	OIL NO. 3.	OIL NO. 4.	OIL NO. 5.	OIL NO. 6.
1......	4.3	6.7	18.2	100	28.6	50
2......	3.5	5.0	20	100	40	50
3......	3.8	5.0	18.2	100	33.3	50
4......	4.0	4.75	17	100	22	50
5......	3.6	4.0	17	100	20	50
6......	4.0	4.75	17	100	20	50
7......	3.8	5.0	18	100	27	50
8......	3.0	...	21	100	..	..
9......	4.0	5.3	10.5	67	25	40
10......	2.5	4.0	17	100	36	67
11......	4.75	6.0	14.4	100	22.55	33
Average	3.75	5.1	17.1	97	27.4	49

NOTE.—All figures given above show R. E. to ½ minute. R. E. values in cases of all oils except Oil No. 5 show a decided concordant series of results. Variations from average R. E. value is slight. The table represents work conducted in six laboratories.

DISCUSSION.

Experiments were carried out in the forming of the emulsion under various conditions.

Using an air bath at room temperature, the emulsion formed was coffee-colored and necessitated the passing of a large volume of steam before sufficient condensation could be obtained, due to the loss of the larger part of the steam through the oil. This factor increased the length of time necessary for emulsifying the oil, and such steaming tended to throw out oil if carried on vigorously. In some cases this time element was so great that the oil was partly separated before the conclusion of the test.

After trials at various temperatures, it was found that if a bath of initial temperature 67° F. was used, the emulsifying was completed in a relatively short time (4 to 7 minutes) and by holding the temperature in the tube at 190 to 195° F., a definite and uniform rate of steam flow was maintained. The conditions of emulsification were therefore fixed and reproducible.

The steam used gives vigorous agitation and is entirely condensed in the tube (low-temperature of surrounding bath) and no oil or steam is lost; moreover, the emulsion formed in this manner has the appearance of emulsions encountered in practice.

The range of temperature given is that over which the difference between duplicable determination is negligible.

A series of experiments to determine the volume or point to which emulsification was to be carried disclosed the fact that most consistent results were obtained when oil was steamed until an equal volume of condensation had been formed. A range of 8 per cent or less of total volume did not visibly affect results.

The steam pipe is given a diagonal opening for the following reasons:

1. To give directive exit to the steam and aid agitation.
2. To prevent bumping.
3. To assure definite position of orifice in relation to bottom of tube.

The emulsion bath is assigned an initial temperature of 67° F. and definite volume (3 liters) because under working conditions, there occurs a rise in temperature of from 5 to 7° F., which range is found favorable for best results.

The separating bath temperature is maintained at 200 to 203° F., which value gives the maximum rate of separation without introducing the danger of heating the emulsions to their boiling points, and thereby creating ebullition, a factor which gives inconsistent results. As already stated, the bath must never exceed 203° F. or the results are misleading.

It will be noted that no attention has been paid to the presence of milky water, or to the character of the emulsion, mainly because in all tests that we have made the numerical value of R. E. seems to be a function of the same conditions which cause these phenomena. The R. E. value is therefore of itself a true measure of the behavior of the oil in practice.

Attention is called to the fact that no appreciable difference in result is noted whether or not rubber tubing is used, provided it has been thoroughly cleaned with steam.

It will be noted that conditions under which emulsions are formed are entirely reproducible, and they do not differ greatly from conditions often encountered in lubricating practice.

A survey of lubricating oils in general use is now in progress and results will form the basis of a future communication on this subject.

Acknowledgment.—The authors wish to express their sincere appreciation of the constructive criticism of W. H. Herschel, Physicist, Bureau of Standards, and J. T. Kavanagh, Physicist, The Atlantic Refining Co.

DISCUSSION.

Mr. Herschel. MR. WINSLOW H. HERSCHEL (*presented in written form*).—The "Resistance to Emulsification" (R. E.) test, described in the appendix to the report of Sub-Committee V of Committee D-2, is an especially welcome addition to the list of emulsion tests because the result is expressed by a single numerical value. The relative advantages of the R. E. test and the Herschel or demulsibility test will be considered under the various headings mentioned in the summary of the paper.

In both tests 20 cc. of oil is agitated with distilled water, so that both have the advantage of a small quantity of oil, and both indicate "the true value of an oil in practice." I am inclined to believe that the R. E. test has a little the advantage in rapidity of determination, while the demulsibility test is easier of operation. The great difficulty with the R. E. test is to estimate the right moment for stopping the steaming. No such difficulty is met with the demulsibility test, in which the stirring is continued for a definite length of time which does not have to be accurately measured since an increase in the length of time would not change the result.

Either apparatus is simple in construction, the only expensive part of the demulsibility apparatus being a small motor, while the R. E. test requires steam, which is not always available, to control the temperature of the settling bath; or an electric heater may be used. While electric heaters are less expensive than motors, their life is much shorter so that the difference in expense is not great in the long run and there is very little to choose between the two tests in regard to simplicity of apparatus. With the R. E. tests, however, the apparatus may be procured and assembled at shorter notice

To place the two tests on an even basis as far as calculation of results is concerned, a table may readily be calculated for determining the R. E. value from the readings taken in the test. The method of expressing the demulsibility is based on the fact that the rate of settling increases up to a maximum value and then decreases, and it is this maximum value which

Mr. Herschel.

is taken as the result of test and called the demulsibility. While this method requires a greater number of readings to be taken than in other emulsion tests, it is believed that it has two important advantages. It helps eliminate the personal factor because when a reading is taken, the operator does not know whether or not it will be the final reading which definitely determines the test value. It also eliminates the difficulty, experienced in other tests, of deciding upon the exact moment when an emulsion may be honestly said to be all settled out, or practically all settled out, which gives room for personal opinion and disagreement.

Every emulsion test, like every viscosimeter, has a limiting viscosity above which it can not be used, and the choice of an instrument or of a standard temperature, must be a matter of compromise, securing a great enough range without too great a sacrifice of sensitiveness. Stratford found that the limit with his shaker test was 50 seconds, Saybolt, at 210° F., and attempted to overcome the difficulty by mixing his oils with 50 per cent of petroleum ether. This would, however, introduce a new complication, and necessitate the standardization of the petroleum ether.

In Bryan's test, as adopted by the Committee on Standardization of Petroleum Specifications, a temperature of 180° F. is adopted for Liberty Aero oils with a viscosity of 80 to 90 seconds, Saybolt, at 210° F. With the demulsibility test, which is run at 130° F., the viscosity limit is about the same as with Stratford's test, while the limit with the R. E. test is about the same as with Bryan's test at 180° F.; that is, the results are discordant if the viscosity is greater than about 100 seconds, Saybolt, at 210° F. The demulsibility test has the same limit of 100 seconds when the temperature is raised to 180° F. The adoption of this temperature would, however, make it necessary either to use different temperatures for oils of different viscosities, which would necessitate determining the viscosity before the demulsibility could be determined, or the higher temperature would have to be used for all oils. In the latter case adaptability to a wider range of viscosities would be obtained at the cost of a decrease in sensitiveness. That is, there would be a greater number of oils which showed the highest possible demulsibility,

Mr. Herschel. 1200, and hence appeared to be perfect, whereas some would in reality settle out more readily than others in service, as shown by tests at 130° F.

By a comparison of demulsibility and R. E. value for the same oils, it has been found that if the actual volume at the end of steaming is just 40 cc., there is a straight line relation between the values obtained by the two tests, as given approximately by the equation

$$\text{R. E. value} = \frac{\text{Demulsibility}}{12}$$

A variation of 5 cc. in the volume will cause an error of about 7 in the R. E. value, this value being too high if the volume is too low, that is, if the steaming has been stopped too soon. It is believed that this variation in volume is the chief cause of the lack of uniformity in the table given by the authors, but no data are given to show to what extent the difficulty is felt by more experienced operators.

Since emulsion tests are purely arbitrary, and do not give a numerical value which is directly proportional to the property which is being measured, whatever it may be considered, a much greater error is to be expected at certain parts of the scale than at others. In the demulsibility test, for example, the higher the demulsibility the greater the discordance to be expected between check results. While one oil might give a value of 1200 on one test and 600 on another, an oil of lower demulsibility would check within a few per cent, as shown in Table 3, page 18, Bureau of Standards *Technologic Paper No. 86* (1917). In comparing the concordance to be obtained with two types of emulsion test, therefore, the same or similar oils must be used.

It is desirable that evidence should be procured to show whether the R. E. test is applicable to a wider range of lubricating oils than other tests.

REPORT OF COMMITTEE D-3

ON

METHODS OF SAMPLING AND ANALYSIS OF COAL.

Committee D-3 desires to recommend to the Society the following revision in the Standard Methods for Laboratory Sampling and Analysis of Coal (D 22 – 16)[1] to be published as tentative for one year and then referred to letter ballot for adoption as standard.

Under Apparatus (page 681, line 6) change "An 8-in. 60-mesh Sieve with Cover and Receiver" to read: "An 8-in. No. 60 Bureau of Standards Standard Screen Scale Sieve with Cover and Receiver."

This change is recommended in view of the recent standardization of screens by the Bureau of Standards.

The committee also recommends that the Tentative Methods for Determination of Fusibility of Coal Ash (D 22 – 19 T)[2] be continued as tentative for another year, and referred at the annual meeting in 1921 to letter ballot for adoption as standard. If adopted, these methods will be added to the Methods D 22 – 16 referred to above.

This report has been submitted to letter ballot of the committee, which consists of 4 members, all of whom have voted affirmatively.

Respectfully submitted on behalf of the committee,

S. W. PARR,
Chairman.

EDITORIAL NOTE.

The proposed revision in the Standard Methods for Laboratory Sampling and Analysis of Coal, referred to in this report, was accepted for publication as tentative and appears on page 822.

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[1] 1918 Book of A.S.T.M. Standards.

[2] See p. 796.

REPORT OF COMMITTEE D-4

ON

ROAD MATERIALS.

During the past year, Committee D-4 has held two important meetings and will hold a third prior to the presentation of this report to the Society. Owing to the unprecedented activity in highway construction throughout the country, a sudden and urgent demand has been made by engineers for standard tests and specifications for road materials. During the war period, work of Committee D-4 was greatly handicapped by participation of many of its members in war work and, as comprehensive investigations necessary for the formulation of standards require considerable time, it has been difficult for the committee to promptly meet the demand which has arisen for tests and specifications for certain road materials. Its earnest application to the problems involved have, however, made it possible this year to present a considerable number of tentative standards to the Society. It is realized that the form and arrangement of some of these standards may be improved and that the use of common and metric equivalents may be made more uniform. It is felt, however, that they are in satisfactory state for presentation as tentative and if they are accepted as such by the Society, their final form and arrangement will be carefully scrutinized by a special editorial committee before they are recommended for adoption as standard.

A large number of additional tests and specifications are now under investigation, and it is hoped and expected that by the next annual meeting many of them will be in proper shape for presentation. This applies particularly to bituminous highway materials, specifications for which must of necessity be influenced by specifications for non-bituminous materials with which they are used.

The present membership of the committee is 48, evenly divided between producers and non-producers. There are two sub-committees, one on bituminous materials and the other on non-bituminous materials. In order to give adequate consideration to the many problems which have to be covered, each sub-committee is divided into sectional committees which report to their parent sub-committee. There are at present 35 such sectional committees. The work of the committee is governed by regulations which have been recently revised to facilitate the early preparation of sub-committee reports, so that they may receive careful study by all members of the committee before recommendations are made to the Society. The committee respectfully submits for the consideration of the Society the following recommendations.

1. *Standard Method for Making a Mechanical Analysis of Sand or Other Fine Highway Material, Except for Fine Aggregates Used in Cement Concrete (D 7 - 18).*[1]—This method was adopted in 1911 and revised in 1916. It was again revised in 1918 to make it conform with the standard scale for testing sieves adopted by a conference of representatives of various scientific and technical societies, Government Bureaus, and private firms called in 1916 by the U. S. Bureau of Standards. As explained in the 1918 report[2] of Committee D-4, it was found that this revision would entail such slight modifications, that the value of records already tabulated upon the basis of the old standard would not be affected. Under date of June 10, 1919, Committee D-4 received a communication from the Bureau of Standards submitting a revision of the scale adopted by the conference in 1916 and asking that this revision be ratified by the committee. Consideration of the revised scale by all standing committees involved was also requested by the Executive Committee. Committee D-4 has therefore had this matter under advisement and after consideration of the various factors involved by the changes which would be necessitated in the Standard Method D 7 - 18 does not wish at this time to propose such a revision of the existing standard. While it is possible to select from the revised scale sieves with openings closely approximating those included in the present standard, it would be necessary to change the designation of two of the standard sieves. This is not considered desirable and would, it is believed, lead to much confusion in the paving industry.

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[1] 1918 Book of A.S.T.M. Standards.

[2] *Proceedings*, Am. Soc. Test. Mats., Vol. XVIII, Part I, p. 327 (1918).

2. *Standard Test for Penetration of Bituminous Materials* (D 5 – 16).[1]—Since the adoption of this test, considerable difficulty has been encountered in obtaining suitable needles from manufacturers of testing equipment which would conform to the description of the needle in the standard test. The subcommittee on bituminous materials, through one of its sectional committees, has therefore been investigating the possibility of slightly changing the dimensions of the needle so that it may be more accurately described without materially affecting test results. While not yet ready to make a definite recommendation for revision of the present standard in this connection, Committee D-4 feels that the results already obtained from the investigation are so promising that they may be of considerable value to those having occasion to make the penetration test. A description of the modified needle together with test results obtained by its use is therefore appended to this report. The investigations are being continued and it is believed that a definite recommendation for revision of the Standard Test D 5 – 16 will be made by the committee in its next annual report.

3. *Tentative Test for Loss on Heating of Oil and Asphaltic Compounds* (*D 6 – 19 T*).[2]—This is a revision of the present Standard Test (D 6 – 16)[1] having the same title. As no criticisms of this revision have been received since its publication, Committee D-4 recommends that the tentative test be referred without change to letter ballot of the Society for adoption as standard, to supersede the present Standard Test D 6 – 16.

4. *Tentative Method for Determination of Softening Point of Tar Products* (*Cube-in-Water Method*) (*D 61 – 19 T*).[3]—This method was proposed for the first time in 1919 but, as explained in the previous report of the committee, it has been satisfactorily used in the tar industry for a number of years. No criticism of the tentative method has been received since its publication, and Committee D-4 therefore recommends that it be referred without change to letter ballot of the Society for adoption as standard. Attention is directed, however, to an error in the

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[1] 1918 Book of A.S.T.M. Standards.

[2] *Proceedings*, Am. Soc. Test. Mats, Vol. XIX, Part I, p. 732 (1919).

[3] *Ibid.*, p. 764 (1919).

method as published in the 1919 *Proceedings*. (See p. 766.) The first sentence in Section 2 (*c*) should read as follows:

"A glass vessel, capable of being heated, not less than 8.5 cm. (3.34 in.) in diameter and measuring 10.5 cm. (4.13 in.) in depth from the bottom of the flare."

5. *Tentative Specifications Recommended for Adoption.*—No criticisms of the following tentative specifications have been received since their publication and the committee therefore recommends that they be referred without change to letter ballot of the Society for adoption as standard:

(*a*) Tentative Specifications for Materials for Cement Grout Filler for Brick and Stone Block Pavements (D 57 - 19 T).[1]

(*b*) Tentative Specifications for Materials for Cement Mortar Bed for Brick, Stone Block and Wood Block Pavements (D 58 - 19 T).[2]

6. *Tentative Specifications for Block for Granite Block Pavements (D 59 - 19 T).*[3]—While this specification has been published in the *Proceedings* of the Society for the past year, Committee D-4 is not yet prepared to recommend it for adoption as standard and therefore requests that it be continued as a tentative specification for the time being.

7. *Proposed Tentative Tests.*—It is recommended that the following tentative tests appended hereto[4] be published as tentative before referring them to letter ballot of the Society for adoption as standard:

(*a*) Test for Specific Gravity of Road Oils, Road Tars, Asphalt Cements and Soft Tar Pitches.

(*b*) Test for Specific Gravity of Asphalts and Tar Pitches Sufficiently Solid to be Handled in Fragments.

(*c*) Test for Quantity of Clay and Silt in Gravel for Highway Construction.

(*d*) Test for Quantity of Clay in Sand-Clay, Topsoil, and Semi-Gravel for Highway Construction.

(*e*) Test for Quantity of Clay and Silt in Sand for Highway Construction.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XIX, Part 1, p. 650 (1919).

[2] *Ibid.*, p. 652.

[3] See p. 690.

[4] See pp. 764–775.—Ed.

The two tests for determination of specific gravity, substantially as described, have been widely used in testing bituminous highway materials. Careful attention to all details of the tests is, however, essential for obtaining accurate results and the committee feels it highly desirable that detailed descriptions be made available at once in the form of tentative tests.

The determination of clay and silt in non-bituminous road materials is frequently of considerable importance in the selection of suitable products. Considerable variation exists in the methods used by different laboratories and Committee D-4 believes that publication of the proposed tentative tests will go far toward unifying present practice.

8. *Proposed Tentative Methods for Sampling Stone, Slag, Gravel, Sand and Stone Block for Use as Highway Materials, including Some Material Survey Methods.*—It is recommended that these methods appended hereto[1] be published as tentative before referring them to letter ballot of the Society for adoption as standard. The committee feels that standardization of methods of sampling the materials above mentioned is very desirable, but that it is extremely difficult to cover adequately every condition that is likely to be encountered, particularly in the matter of sampling natural deposits. It therefore hopes if these methods are published as tentative that criticism and comments will be freely made by those experienced in sampling such products.

9. *Proposed Tentative Specifications.*—Committee D-4 recommends that the following tentative specifications appended hereto[2] be published as tentative before referring them to letter ballot of the Society for adoption as standard:

(*a*) Specifications for Proportions for Concrete for Highway Construction.[3]

(*b*) Specifications for Workability of Concrete for Concrete Pavements.

(*c*) Specifications for Commercial Sizes of Broken Stone and Broken Slag for Highway Construction.

(*d*) Specifications for Commercial Sizes of Sand and Gravel for Highway Construction.

(*e*) Specifications for Broken Slag for Waterbound Base.

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[1] See p. 789.—ED.

[2] See pp. 692–703.—ED.

[3] See Editorial Note, p. 434.—ED.

(*f*) Specifications for Shovel-Run or Crusher-Run Broken Slag for Waterbound Base.

(*g*) Specifications for Natural or Artificial Sand-Clay Mixtures for Highway Surfacing.

These specifications are the second lot of a series designed to cover various types of highway materials the demand for which was mentioned in the first part of this report. It is expected that in its next annual report the committee will be prepared to recommend specifications for a number of other highway materials.

Items.	Affirmative.	Negative.	Not Voting.
I. TENTATIVE STANDARDS RECOMMENDED FOR ADOPTION AS STANDARD.			
Tentative Test for Loss on Heating of Oil and Asphaltic Compounds (D 6 - 19 T)	35	2	11
Tentative Method for Determination of Softening Point of Tar Products (Cube-in-Water Method) D 61 - 19 T	35	2	11
Tentative Specifications for Materials for Cement Grout Filler for Brick and Stone Block Pavements (D 57 - 19 T)	33	0	15
Tentative Specifications for Materials for Cement Mortar Bed for Brick, Stone Block and Wood Block Pavements (D 58 - 19 T)	32	1	15
II. PROPOSED NEW TENTATIVE STANDARDS.			
Proposed Tentative Test for Specific Gravity of Road Oils, Road Tars, Asphalt Cements and Soft Tar Pitches	37	0	11
Proposed Tentative Test for Specific Gravity of Asphalts and Tar Pitches Sufficiently Solid to be Handled in Fragments	37	0	11
Proposed Tentative Test for Quantity of Clay and Silt in Gravel for Highway Construction	38	1	9
Proposed Tentative Test for Quantity of Clay in Sand-Clay, Topsoil and Semi-Gravel for Highway Construction	39	0	9
Proposed Tentative Test for Quantity of Clay and Silt in Sand for Highway Construction	39	0	9
Proposed Tentative Methods for Sampling of Stone, Slag, Gravel, Sand and Stone Block for Use as Highway Materials, including Some Material Survey Methods	37	1	10
Proposed Tentative Specifications for Proportions for Concrete for Highway Construction	30	5	13
Proposed Tentative Specifications for Workability of Concrete for Concrete Pavements	32	1	15
Proposed Tentative Specifications for Commercial Sizes of Broken Stone and Broken Slag for Highway Construction	37	1	10
Proposed Tentative Specifications for Commercial Sizes of Sand and Gravel for Highway Construction	38	0	10
Proposed Tentative Specifications for Broken Slag for Waterbound Base	34	0	14
Proposed Tentative Specifications for Shovel-Run or Crusher-Run Broken Slag for Waterbound Base	35	0	13
Proposed Tentative Specifications for Natural or Artificial Sand-Clay Mixtures for Highway Surfacing	36	0	12

The results of a letter ballot of the committee upon the recommendations which have been made relative to the adoption of tentative standards and the submission of new standards is given in the accompanying table.

This report has been submitted to letter ballot of the committee, which consists of 48 members, of whom 35 have voted affirmatively, none negatively, and 13 have refrained from voting.

Respectfully submitted on behalf of the committee,

A. H. BLANCHARD,
Chairman.

PREVOST HUBBARD,
Secretary.

EDITORIAL NOTE.

The Tentative Test for Loss on Heating of Oil and Asphaltic Compounds, the Tentative Method for Determination of Softening Point of Tar Products, the Tentative Specifications for Materials for Cement Grout Filler for Brick and Stone Block Pavements, and the Tentative Specifications for Materials for Cement Mortar Bed for Brick, Stone Block and Wood Block Pavements were approved at the annual meeting and subsequently adopted by letter ballot of the Society on September 1, 1920, and appear in the supplementary pamphlet of A.S.T.M. Standards Adopted in 1920.

The 5 proposed tentative tests listed as items (*a*) to (*e*) under paragraph 7 of this report, the 6 tentative specifications listed as items (*b*) to (*g*) under paragraph 9, and the tentative method mentioned under paragraph 8 were accepted for publication as tentative and appear on pages 764-775, 692-703, and 789, respectively.

The recommendation for the publication as tentative of Specifications for Proportions for Concrete for Highway Construction, referred to in paragraph 9 (*a*), was withdrawn by the committee at the annual meeting (see Summary of the Proceedings, page 26). The material included under this title in the report as preprinted now appears as Appendix II to the report, pages 437-440.

APPENDIX I.

REPORT OF COLLABORATIVE TESTS OF SECTIONAL COMMITTEE ON PENETRATION RELATIVE TO MODIFICATION OF THE STANDARD NEEDLE.

Recognizing the extreme difficulty in tapering the needle to the mathematical point actually required under the present definition and also the fragile nature of the "point" when so obtained, the sectional committee decided to introduce a slight modification in the standard needles sent out for these cooperative tests. This consisted in definitely blunting the needles by grinding off to a frustum of definite diameter as illustrated in Fig. 1.

In obtaining comparisons of the new needle with the old Roberts needle, seven laboratories conducted tests in accordance with all other details of the present standard. Fifteen samples were used in these tests as shown in Table I. The conclusions drawn by the sectional committee from the results of these tests are as follows:

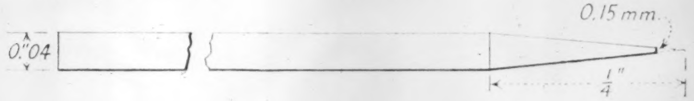

FIG. 1.—Modified Needle for Penetration Test.

1. None of the collaborating laboratories show any consistent difference in results obtained with the use of the two needles, and the greatest variations between laboratories are scarcely of commercial or even scientific significance. Exception might be made in the case of the tar products, but the section does not consider the penetration test appropriate for determining the consistency of these materials.

2. In the case of asphalts of relatively high melting point, such as covered by Series C, there is no appreciable difference in the results by the two needles. The agreement of the two needles in this series is, if anything, especially close.

3. In a majority of instances, the smaller variations among laboratories are in the tests with the modified standard needle.

TABLE I.—COLLABORATIVE PENETRATION TESTS.

Laboratory.	Needle.									
	Roberts.	New.	Roberts.	New.	Roberts.	New.	Roberts.	New.	Roberts.	New.
	Sample 1.		Sample 2.		Sample 2-*b*.		Sample 3.		Sample 4.	
	SERIES A.—MEXICAN ASPHALTS.									
A	8	8	33	33	..	..	52	52	99	96
B	6	7	31	32	..	..	52	51	104	97
C	7	8	38	36	..	..	55	54	104	101
D	10	10	36	35	..	..	56	55	103	100
E	9	10	34	35	..	..	55	55	98	97
F	9	9	35	36	..	..	55	57	98	99
G	7	8	32	33	..	..	55	55	100	100
	SERIES B.—TRINIDAD ASPHALTS.									
A	17	18	35	35	...	..	55	55	101	99
B	19	19	38	37	..	..	55	51	115	111
C	19	19	38	37	..	..	55	55	98	97
D	20	20	37	37	..	..	55	54	103	100
E	18	20	34	35	..	..	55	54	101	100
F	19	20	39	41	..	..	57	60	106	107
G	21	19	39	39	..	..	55	55	107	103
	SERIES C.—ASPHALTS OF RELATIVELY HIGH MELTING POINT.									
A	16	16	37	37	30	30	55	55	87	83
B	15	17	31	40	28	33	57	57	86	84
C	18	18	43	42	35	34	62	60	92	92
D	19	19	40	40	34	34	58	58	91	91
E	18	18	41	42	32	34	58	59	94	91
F	17	17	42	44	32	35	59	62	93	96
G	17	17	41	41	33	33	55	56	90	89
	SERIES D.—TARS.									
A	18	19	79	81	..	..	..	..	..	..
B	18	20	76	80	..	..	..	..	..	..
C	19	19	84	81	..	..	..	..	..	..
D	20	20	79	77	..	..	..	..	..	..
E	19	20	69	72	..	..	..	..	..	..
F	20	21	70	73	..	..	..	..	..	..
G	21	20	94	91	..	..	..	..	..	..

NOTE.—The laboratories represented by the letters in this table are as follows:

A. Barber Asphalt Paving Co.
B. Barrett Company.
C. Dow and Smith.
D. Interocean Oil Company.
E. N. Y. State Highway Department.
F. Standard Oil Company.
G. U. S. Bureau of Public Roads.

APPENDIX II.

PROPORTIONS AND QUANTITIES OF MATERIALS FOR CONCRETE FOR HIGHWAY CONSTRUCTION.

By Duff A. Abrams.

The customary methods of proportioning concrete mixtures are based on the assumption that a satisfactory grading of aggregate can be secured only by mixing fine and coarse aggregates each of which conforms to certain requirements as to size and grading. It is usually specified that fine aggregate shall be graded from the finest particles up to $\frac{1}{4}$ in. and that coarse aggregate shall be graded from $\frac{1}{4}$ to $1\frac{1}{2}$, 2 or $2\frac{1}{2}$ in. The fine aggregate is generally required to meet certain mortar strength requirements. The fine and coarse aggregate thus selected are mixed in purely arbitrary proportions.

The theories on which the foregoing methods are based embody certain fallacies which have come to light in the studies of concrete and concrete materials being carried out through the cooperation of the Portland Cement Association and Lewis Institute at the Structural Materials Research Laboratory. These fallacies will be recognized from the following principles which have been established as a result of about 75,000 tests of concrete and mortars in which the widest possible variations were made in mix (quantity of cement), size and grading of aggregate, and consistency (water-content):

1. With given materials and conditions of test the quantity of mixing water used determines the strength of the concrete, so long as the mix is plastic and the aggregate grading is not too coarse for the quantity of cement used.

2. There is no direct relation between the mortar strength and the concrete-making quality of a sand. For a given mix the concrete strength will depend to a large extent on the proportions of sand used.

3. Other things being equal, a fine sand gives a lower concrete or mortar strength than a coarse one solely due to the fact that more water must be used in mixing the fine sand.

4. The finer the sand, the smaller the relative proportion necessary for best results in concrete.

Not all of the foregoing principles are new. However, the disregard of these principles has led to the adoption of entirely arbitrary standards for the selection of aggregate, and has resulted in the rejection of many types of aggregate (particularly sands) which, if properly used, would give as good concrete as the materials which are acceptable under the usual requirements. Our tests have shown that fine and coarse aggregate of widely different size and grading can be combined in such a manner as to produce similar results in concrete.

Table I giving the proportions and quantities of materials for one cubic yard of concrete suitable for one-course concrete roads and pavements, is based on the principles described above. Concrete for this purpose must be of high strength and resistance to abrasion. The table is based on concrete having a compressive strength of 3000 lb. per sq. in. at 28 days, when tested in the form of 6 by 12-in. cylinders which have been kept damp. It is assumed that the cement used will conform to the Standard Specifications and Tests for Portland Cement of the American Society for Testing Materials. The usual requirements for structural quality and cleanness of aggregates should be enforced.

The distinction between fine and coarse aggregate is a purely arbitrary one. We have, however, recognized the principle that aggregate should be handled in two sizes, in order that successive batches may be uniform; the exact point at which the separation between fine and coarse aggregate is made is immaterial so long as we proportion the quantities accordingly.

Proportions and quantities have been worked out for five fine aggregates ranging in maximum size from 28-mesh sieve to $\frac{3}{8}$-in., and 27 different gradings of coarse aggregate.

To determine in what classification a given aggregate falls, the following methods may be used:

(*a*) In all cases aggregates are assumed to be reasonably well graded between the limits specified.

(*b*) For fine aggregate, 15 per cent or more of the total volume shall fall between the *maximum* size and the next smaller size shown in the table. Thus, in order to be classed as 0 to 4

TABLE I.—PROPORTIONS AND QUANTITIES FOR ONE CUBIC YARD OF CONCRETE.

Based upon laboratory investigations, using approved materials, compressive strength at 28 days with workable plasticity, 6 by 12-in. cylinders, 3000 lb. per sq. in.

Size of Coarse Aggregates.	Cement in Barrels, Aggregates in Cu. Yd.	Fine Aggregates, Sieve Openings per inch.														
		0 – 28			0 – 14			0 – 8			0 – 4			0 – $\frac{3}{8}$ in.		
		Cement.	Fine.	Coarse.	Cement.	Fine.	Coarse.	Cement.	Fine.	Coarse.	Cement.	Fine.	Coarse.	Cement.	Fine.	Coarse.
No. 4 sieve to $\frac{3}{4}$ in.	Proportions	1	1.3	2.4	1	1.6	2.4	1	1.8	2.3	1	2.0	2.3	1	2.7	1.5
	Quantities	1.96	0.37	0.69	1.85	0.44	0.66	1.82	0.48	0.62	1.75	0.52	0.59	1.79	0.72	0.40
No. 4 sieve to 1 in.	Proportions	1	1.3	2.7	1	1.6	2.6	1	1.8	2.6	1	2.0	2.5	1	2.6	1.8
	Quantities	1.90	0.36	0.76	1.77	0.42	0.68	1.72	0.46	0.66	1.67	0.50	0.62	1.72	0.66	0.46
No. 4 sieve to $1\frac{1}{2}$ in.	Proportions	1	1.2	3.1	1	1.6	3.2	1	1.7	3.1	1	2	3	1	2.4	2.4
	Quantities	1.82	0.32	0.84	1.68	0.40	0.79	1.63	0.41	0.75	1.61	0.47	0.72	1.62	0.57	0.57
No. 4 sieve to 2 in.	Proportions	1	1.2	3.5	1	1.5	3.5	1	1.6	3.7	1	1.9	3.6	1	2.2	3.1
	Quantities	1.75	0.31	0.90	1.63	0.36	0.85	1.55	0.36	0.85	1.52	0.43	0.81	1.53	0.50	0.70
No. 4 sieve to $2\frac{1}{2}$ in.	Proportions	1	1.1	3.8	1	1.4	3.9	1	1.6	4.0	1	1.8	4.0	1	2.1	3.5
	Quantities	1.72	0.28	0.97	1.58	0.33	0.91	1.51	0.35	0.89	1.49	0.40	0.88	1.50	0.46	0.78
No. 4 sieve to 3 in.	Proportions	1	1.1	3.9	1	1.4	4.1	1	1.5	4.1	1	1.7	4.1	1	2.0	3.7
	Quantities	1.69	0.28	0.97	1.58	0.33	0.97	1.49	0.33	0.90	1.49	0.37	0.90	1.49	0.44	0.81
$\frac{3}{8}$ to $\frac{3}{4}$ in.	Proportions	1	1.3	2.3	1	1.7	2.3	1	1.9	2.3	1	2.2	2.2	1	2.8	1.4
	Quantities	1.96	0.37	0.67	1.85	0.46	0.63	1.82	0.51	0.62	1.75	0.57	0.57	1.79	0.75	0.37
$\frac{3}{8}$ to 1 in.	Proportions	1	1.3	2.6	1	1.7	2.6	1	1.9	2.5	1	2.2	2.4	1	2.7	1.7
	Quantities	1.90	0.36	0.74	1.77	0.44	0.68	1.72	0.48	0.64	1.67	0.54	0.59	1.72	0.68	0.43
$\frac{3}{8}$ to $1\frac{1}{2}$ in.	Proportions	1	1.3	3.0	1	1.7	3.0	1	1.9	3.0	1	2.1	2.9	1	2.6	2.2
	Quantities	1.82	0.35	0.80	1.68	0.43	0.75	1.63	0.46	0.73	1.61	0.50	0.68	1.62	0.63	0.53
$\frac{3}{8}$ to 2 in.	Proportions	1	1.3	3.3	1	1.7	3.4	1	1.8	3.5	1	2.0	3.4	1	2.4	2.9
	Quantities	1.75	0.34	0.86	1.63	0.41	0.83	1.55	0.42	0.80	1.52	0.45	0.77	1.53	0.62	0.66
$\frac{3}{8}$ to $2\frac{1}{2}$ in.	Proportions	1	1.3	3.7	1	1.6	3.7	1	1.7	3.9	1	2.0	3.8	1	2.3	3.3
	Quantities	1.72	0.33	0.95	1.58	0.37	0.87	1.51	0.37	0.87	1.49	0.44	0.84	1.50	0.51	0.74
$\frac{3}{8}$ to 3 in.	Proportions	1	1.2	3.8	1	1.6	3.9	1	1.7	4.0	1	1.9	4.0	1	2.2	3.5
	Quantities	1.68	0.30	0.95	1.58	0.37	0.91	1.49	0.37	0.88	1.49	0.42	0.88	1.49	0.48	0.77
$\frac{1}{2}$ to $\frac{3}{4}$ in.	Proportions	1	1.5	2.3	1	1.9	2.2	1	2.1	2.2	1	2.3	2.1	1	2.8	1.3
	Quantities	1.96	0.44	0.67	1.85	0.52	0.61	1.82	0.56	0.59	1.75	0.59	0.54	1.79	0.75	0.34
$\frac{1}{2}$ to 1 in.	Proportions	1	1.5	2.5	1	1.9	2.5	1	2.1	2.4	1	2.3	2.4	1	2.8	1.6
	Quantities	1.90	0.42	0.70	1.77	0.50	0.66	1.72	0.53	0.61	1.67	0.57	0.59	1.72	0.72	0.41
$\frac{1}{2}$ to $1\frac{1}{2}$ in.	Proportions	1	1.4	2.8	1	1.9	2.9	1	2.1	2.9	1	2.2	2.8	1	2.7	2.1
	Quantities	1.82	0.37	0.75	1.68	0.47	0.73	1.63	0.51	0.69	1.61	0.52	0.66	1.62	0.65	0.51
$\frac{1}{2}$ to 2 in.	Proportions	1	1.4	3.3	1	1.9	3.3	1	2.0	3.4	1	2.2	3.3	1	2.7	2.7
	Quantities	1.75	0.36	0.86	1.63	0.46	0.79	1.55	0.46	0.78	1.52	0.50	0.74	1.53	0.62	0.62
$\frac{1}{2}$ to $2\frac{1}{2}$ in.	Proportions	1	1.4	3.6	1	1.8	3.6	1	1.9	3.7	1	2.1	3.7	1	2.6	3.1
	Quantities	1.72	0.35	0.91	1.58	0.43	0.85	1.51	0.42	0.83	1.49	0.46	0.81	1.50	0.57	0.69
$\frac{1}{2}$ to 3 in.	Proportions	1	1.3	3.7	1	1.8	3.8	1	1.8	3.9	1	2.1	4.0	1	2.4	3.3
	Quantities	1.68	0.33	0.92	1.58	0.42	0.89	1.49	0.40	0.86	1.49	0.46	0.88	1.49	0.53	0.63
$\frac{3}{4}$ to 1 in.	Proportions	1	1.7	2.4	1	2.1	2.4	1	2.4	2.1	1	2.6	2.2	1	3.1	1.5
	Quantities	1.90	0.48	0.68	1.77	0.55	0.63	1.72	0.61	0.53	1.67	0.64	0.55	1.72	0.79	0.39

TABLE I.—PROPORTIONS AND QUANTITIES FOR ONE CUBIC YARD OF CONCRETE (*Continued*).

Size of Coarse Aggregates.	Cement in Barrels, Aggregates in Cu. Yd.	Fine Aggregates, Sieve Openings per inch.														
		0 - 28			0 - 14			0 - 8			0 - 4			0 - $\frac{3}{4}$ in.		
		Cement.	Fine.	Coarse.	Cement.	Fine.	Coarse.	Cement.	Fine.	Coarse.	Cement.	Fine.	Coarse.	Cement.	Fine.	Coarse.
$\frac{3}{4}$ to $1\frac{1}{2}$ in.	Proportions	1	1.7	2.7	1	2.0	2.8	1	2.3	2.7	1	2.5	2.7	1	3.0	2.0
	Quantities	1.82	0.46	0.73	1.79	0.50	0.70	1.63	0.55	0.65	1.61	0.59	0.64	1.62	0.73	0.48
$\frac{3}{4}$ to 2 in.	Proportions	1	1.7	3.1	1	2.0	3.1	1	2.3	3.1	1	2.5	3.0	1	3.0	2.4
	Quantities	1.75	0.44	0.80	1.63	0.48	0.75	1.55	0.53	0.72	1.52	0.56	0.67	1.53	0.68	0.55
$\frac{3}{4}$ to $2\frac{1}{2}$ in.	Proportions	1	1.7	3.3	1	2.0	3.5	1	2.3	3.4	1	2.4	3.4	1	2.9	2.8
	Quantities	1.72	0.43	0.84	1.63	0.47	0.83	1.51	0.52	0.76	1.49	0.53	0.75	1.50	0.64	0.62
$\frac{3}{4}$ to 3 in.	Proportions	1	1.7	3.5	1	2.0	3.7	1	2.3	3.7	1	2.4	3.6	1	2.8	3.1
	Quantities	1.68	0.43	0.88	1.58	0.47	0.87	1.49	0.51	0.81	1.49	0.53	0.79	1.49	0.62	0.68
1 to $1\frac{1}{2}$ in.	Proportions	1	1.7	2.8	1	2.0	2.9	1	2.3	2.7	1	2.6	2.6	1	3.1	2.0
	Quantities	1.82	0.46	0.75	1.68	0.50	0.73	1.63	0.55	0.65	1.61	0.62	0.62	1.62	0.75	0.48
1 to 2 in.	Proportions	1	1.5	3.2	1	1.9	3.5	1	2.2	3.3	1	2.4	3.3	1	3.0	2.6
	Quantities	1.75	0.39	0.83	1.63	0.46	0.85	1.58	0.51	0.76	1.52	0.54	0.74	1.53	0.68	0.59
1 to $2\frac{1}{2}$ in.	Proportions	1	1.4	3.4	1	1.9	3.8	1	2.0	3.7	1	2.3	3.7	1	2.7	3.1
	Quantities	1.72	0.35	0.86	1.58	0.45	0.89	1.51	0.44	0.83	1.49	0.51	0.81	1.50	0.59	0.69
1 to 3 in.	Proportions	1	1.3	3.6	1	1.8	4.0	1	2.0	3.9	1	2.2	3.9	1	2.7	3.3
	Quantities	1.67	0.33	0.90	1.58	0.42	0.94	1.49	0.44	0.86	1.49	0.48	0.86	1.49	0.59	0.73

aggregate there shall be 15 per cent or more of the material between the 4-mesh and the 8-mesh sieves.

(*c*) For coarse aggregate, 10 per cent or more of the material shall fall between the *maximum* size and the next smaller size shown in the table. Thus, in order to be classed as $2\frac{1}{2}$-in. material not less than 10 per cent shall fall in the $2\frac{1}{2}$ to 2-in. size.

(*d*) If the quantity of coarse material is less than that given under (*b*) and (*c*) the upper limit of size of the material shall be that of the next smaller size.

(*e*) The lower limit of size of a coarse aggregate shall be the largest sieve in the table which will permit the passage of 10 per cent of the material.

(*f*) If more than 5 per cent of the volume of coarse aggregate passes the 4-mesh sieve, then such excess shall be considered as fine aggregate and the amount of fine aggregate to be used shall be modified accordingly.

The sieve sizes are according to what is known as the Tyler Standard Screen Scale, using square mesh woven wire cloth.

DISCUSSION

Mr. F. H. Rood (*presented in written form*).—The proposed Tentative Specifications for Broken Slag for Waterbound Base,[1] Section 2, read as follows: "The broken slag shall be air-cooled blast-furnace slag and shall consist of angular fragments reasonably uniform in density and quality, and reasonably free from thin, elongated or glassy pieces, dirt or other objectionable matter." Section 2 of the Proposed Tentative Specifications for Shovel-Run or Crusher-Run Broken Slag for Waterbound Base[2] reads exactly the same. Apparently the quality of the slag under these two specifications is to be the same. **Mr. Rood.**

The percentage of wear for both of these specifications is to be determined as specified in the A.S.T.M. Standard Test for Abrasion of Road Materials using a volume of 4000 cc., measured loose, of the broken slag of the size specified in the standard test. This paragraph means that from the samples of broken slag and crusher-run slag pieces of equal size will be selected for the test. As stated above these pieces will be of the same quality, yet the specifications for broken slag call for a percentage of wear of not more than 12 per cent while the specifications for shovel-run or crusher-run slag allow 15 per cent of wear. I can see no reason why with the same quality and the same size of material, two specifications for waterbound base should allow different percentages of wear.

My experience with slag has shown that unless it contains a large percentage of porous or honeycomb material, it will have a loss of around 8 per cent. Mattimore in his discussion of the abrasion test[3] shows for dense slag a wear of 6.8 per cent. and 5.6 per cent.

For porous or honeycomb slag alone he shows 16.6 per cent wear and for dense and honeycomb mixed in equal parts 16.7 per cent wear. Now if we accept slag with 15 per cent wear we will get about 50 per cent of porous slag. A mixture of half porous

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[1] See p. 698.—Ed.

[2] See p. 700.—Ed.

[3] *Proceedings*, Am. Soc. Test. Mats., Vol. XVIII, Part II, p. 427 (1918).

Mr. Rood. slag and half dense slag is certainly far from uniform. The less porous material there is in the slag the better it is.

Both of these specifications call for a volume of 4000 cc. of slag measured loose for the abrasion test. Laboratories are not equipped with 4000-cc. measures and if they were two operators would not get the same amount of material by measuring slag loose. Four thousand grams of slag will occupy nearly the same space in the abrasion cylinder as 5000 g. of stone. This amount of slag has given very satisfactory results in the laboratory of the New York State Commission of Highways.

I would suggest that the committee change the allowable percentage of wear for shovel-run slag to the same as that for broken slag. It is also suggested that the section relating to percentage of wear in both specifications be changed to read "using however 4000 g. of the broken slag of the size specified in the standard test."

Mr. Davis. MR. WATSON DAVIS (*by letter*).—In the preprint of the report of Committee D-4 on Road Materials the proposed tentative specifications which call for the truncated cone slump test of concrete[1] were headed "Specifications for Consistency of Concrete for Highway Construction." When the report was presented to the convention "consistency" had been changed to "workability." Objection to this change was made at that time.

It is believed that "consistency" is the proper word to use in connection with this slump test, in the light of present usage and logic.

Consistency is a state or condition of the mass of concrete that varies with water content. It is in this sense that the word is generally used when applied to concrete, and the literature of concrete construction and testing is filled with references to consistency in this sense. The standard text books on materials and concrete use the adjectives "wet" and "dry" to distinguish between degrees of consistency. Reference to the Standard Specifications and Tests for Portland Cement, will show that the "normal consistency" by the Vicat Needle is determined after trials on pastes made with "varying percentages of water." The normal consistency for gypsum plaster

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[1] See p. 692.—ED.

Mr. Davis.

is determined by the Southard Viscosimeter, and the Tentative Methods for Tests of Gypsum and Gypsum Products[1] state "it is necessary that all plasters be first brought to the same consistency by the addition of the proper amount of water."

A similar interpretation is to be placed on the word "consistency" as used in the following articles describing the slump test. "Concrete Consistency Measured by a New Device" was the heading of Herbert A. Davis' article in *Engineering News-Record* for March 27, 1919, when he described the cylinder slump test developed at the Bureau of Standards. When Prof. D. A. Abrams, in a letter in *Engineering News-Record*, April 24, 1919, discussed this slump test, his article was headed "Consistency Test for Concrete Used in Laboratory Practice." When C. M. Chapman described in *Concrete-Cement Age* for July, 1913, a test for consistency that is considered by some to be a forerunner of the present slump test, the article was headed: "Apparatus for Determining Consistency." The truncated cone apparatus for making the slump test was described by F. L. Roman in *Engineering and Contracting* for March 3, 1920, under the title: "An Apparatus for Determining the Consistency of Concrete."

Water requirement is determined by the slump test in the specifications under discussion. Note the first sentence of the specification: "The amount of water to be used for mixing concrete for highway construction shall be that which will give a —— to be determined as follows." The blank should be filled by the word "consistency."

"Flowability" is a synonym for consistency that is used in connection with the flow-table test developed at the Bureau of Standards. This test is described in *Engineering News-Record* for May 27, 1920, in an article by G. M. Williams entitled "Concrete Consistency Measured by the Flow Table."

The term "workability" should be reserved for use in referring collectively to all the qualities of a concrete mix that influence the ability to use the concrete under given conditions. Consistency affects "workability" markedly, but other factors, such as gradation of aggregate, the mix or amount of cement, the kind of aggregate, the quality and quantity of additions or

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[1] See p. 634.—ED.

Mr. Davis. admixtures also influence the working properties of concrete. A coarse, segregating, under-sanded mix would not be suitable for use in a heavily reinforced slab even though of a very wet consistency, nor would a well-proportioned, rich mix if it were of a dry consistency. There are now being developed more or less satisfactory methods of measuring consistency, but there is not a collective measure of the inherent quality that a concrete has due to gradation, richness and the quality of its components. We at present can only measure this inherent quality by tests for gradation and segregation, and the consideration of the proportions of the mix and the quality of the component materials.

It is hoped that through the cooperation of the various interested committees and individuals, especially through the new Standing Committee on Nomenclature and Definitions, definitions of terms such as "consistency" and "workability" may be evolved which will clarify the literature of concrete testing and construction.

REPORT OF COMMITTEE D-6

ON

COKE.

In view of the recent standardization of screens, and the desirability of benefiting from this achievement upon which so much thought and work has been expended, Committee D-6 recommends that the following revision in the Standard Methods for Laboratory Sampling and Analysis of Coke (D 37 – 18)[1] be published as tentative for one year, and then referred to letter ballot for adoption as standard:

Under Apparatus (page 710, line 4) change "An 8-in. 60-mesh Sieve with Cover and Receiver" to read: "An 8-in. No. 60 Bureau of Standards Standard Screen Scale Sieve with Cover and Receiver."

This report has been submitted to letter ballot of the committee, which consists of 14 members, of whom 11 have voted affirmatively, none negatively, and 3 have refrained from voting.

Respectfully submitted on behalf of the committee,

RICHARD MOLDENKE,
Chairman.

A. C. FIELDNER,
Secretary.

EDITORIAL NOTE.

The proposed revision of the Standard Methods for Laboratory Sampling and Analysis of Coke, referred to in this report, was accepted for publication as tentative and appears also on page 822.

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[1] 1918 Book of A.S.T.M. Standards.

REPORT OF COMMITTEE D-7
ON
TIMBER.

The report of Committee D-7 is presented in two parts. Recommendations with reference to tentative specifications, and the Report of Sub-Committee III on Pacific Coast Timbers.

RECOMMENDATIONS WITH REFERENCE TO TENTATIVE SPECIFICATIONS.

A number of tentative specifications which have been published for a number of years were considered by the committee this year, and recommendations follow herewith for the adoption of these tentative specifications as standard.

1. *Tentative Specifications for Southern Yellow-Pine Timber to be Creosoted* (*D 24 - 15 T*).[1]—These specifications were issued as tentative specifications in 1915. No criticisms having been received, the committee recommends that they be submitted to the Society for letter ballot to be adopted as standard. The letter ballot vote of the committee on this recommendation is as follows: Affirmative, 26; negative, 0; not voting, 2.

2. *Tentative Specifications for Southern Yellow-Pine Piles and Poles to be Creosoted* (*D 25 - 15 T*).[2]—These specifications were issued as tentative specifications in 1915. No criticisms having been received, the committee recommends that they be submitted to the Society for letter ballot to be adopted as standard. The letter ballot vote of the committee on this recommendation is as follows: Affirmative, 26; negative, 0; not voting, 2.

3. *Tentative Specifications for Wooden Paving Blocks for Exposed Pavements* (*D 52 - 18 T*).[3]—These specifications were issued as tentative specifications in 1918. After considerable discussion the committee has made the following revision in the specifications: In Sub-Division III, "Preservative," omit Sections 9 and 10 dealing with the description of coal-tar paving oil and distillate oil. This sub-division of the specifications will consist, therefore, only of Section 8, reading:

> "The preservatives used shall be coal-tar paving oil or distillate oil, as specified by the purchaser."

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XIX, Part I, p. 660 (1919).

[2] *Ibid.*, p. 662.

[3] *Ibid.*, p. 664.

Omit the note referring to water-gas tar at the end of the specifications.

The committee recommends that this revision be approved, and the specifications as revised submitted to the Society for letter ballot to be adopted as standard. The letter ballot vote of the committee on this recommendation is as follows: Affirmative, 21; negative, 5; not voting, 2.

REPORT OF SUB-COMMITTEE III ON PACIFIC COAST TIMBERS.

In 1916[1] Committee D-7 presented Tentative Specifications for Selected Structural Douglas Fir Bridge and Trestle Timbers, which conform more or less to the specifications adopted for southern pine timbers. The specifications were based largely on a visual method for determining density, as was the case for southern pine, but because of the difference in the size and the characteristics of growth of Douglas fir and southern pine, it was found after considerable experience that many serviceable pieces of Douglas fir timber were rejected under the clauses of the tentative specifications. Since the original publication of the specifications under the serial designation D 23 - 16 T,[2] a good many tests have been conducted by the U. S. Forest Service and others, as a result of which much information has been developed that is of importance in connection with the revised specifications submitted with this report. It is of particular interest to summarize briefly the significance of density and structural grading rules:

Tests at the Forest Products Laboratory of the U. S. Forest Service and elsewhere have shown that the production of timbers wherein uniformity of strength properties, durability and resistance to wear and abrasion are required is dependent chiefly upon two factors: (1) The density or dry weight per cubic foot of the wood; and (2) The character, size, number and location of defects. Strength is closely proportional to the density of the clear wood and is limited by the defects present. Density is a factor in durability and in resistance to abrasion.

Heartwood and sapwood are not factors in strength, exhaustive tests having shown them to be of practically equal strength; but they are important factors in durability, heartwood being far more durable than sapwood. Heartwood requirement is not, therefore, a part of a structural grading rule except as a special requirement in timbers which will be subject to decay-producing conditions.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XVI, Part I, p. 327 (1916).

[2] *Proceedings*, Am. Soc. Test. Mats., Vol. XIX, Part I, p. 656 (1919).

The production of good structural material of any species, therefore, depends upon enforcing a specification which provides: (1) That the density, or dry weight of the wood, shall not be below a certain minimum; and (2) That the defects shall not exceed certain definite limitations.

The committee herewith[1] presents proposed Tentative Specifications for Structural Douglas Fir, with the recommendation that they be accepted for publication as tentative, to supersede the present specifications D 23 – 16 T. The letter ballot vote of the committee on this recommendation is as follows: Affirmative, 25; negative, 0; not voting, 3.

Attention is called to certain matter submitted as information in the form of an appendix to the specifications which the committee believes to be important to a proper understanding and consideration of these specifications.

This report has been submitted to letter ballot of the committee, which consists of 28 members, of whom 19 have voted affirmatively, none negatively, and 9 have refrained from voting.

Respectfully submitted on behalf of the committee,

HERMANN VON SCHRENK,
Chairman.

J. A. NEWLIN,
Secretary.

EDITORIAL NOTE.

The proposed revisions of the Tentative Specifications for Wooden Paving Blocks for Exposed Pavements were accepted. These specifications, as thus revised, together with the Tentative Specifications for Southern Yellow Pine Timber to be Creosoted and the Tentative Specifications for Southern Yellow Pine Piles and Poles to be Creosoted, were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1920, and appear in the supplementary pamphlet of A.S.T.M. Standards Adopted in 1920.

The revision of the Tentative Specifications for Selected Structural Douglas Fir Bridge and Trestle Timbers was accepted. The tentative specifications, as thus revised, appear on page 704.

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[1] See p. 704.—ED.

REPORT OF COMMITTEE D-10

ON

SHIPPING CONTAINERS.

One meeting of Committee D-10 has been held since the last annual meeting of the Society.

There is now more interest in the subject of tests and specifications for shipping containers than has been evident at any time since the organization of Committee D-10.

It is apparent that an increasing number of people and agencies are becoming alive to the need for research and definite standards for shipping containers.

The committee considered it useful as a definite record to enumerate here those organizations which it knows to be taking an active interest in better shipping containers and to be making tests and considering specifications for the same.

The National Association of Box Manufacturers has a committee on standards and specifications for box construction. This committee has been especially active during the past few months and is cooperating closely with the Sub-Committee of Committee D-10 on Nailed and Lock-Corner Containers. The National Association of Box Manufacturers has also cooperated closely with the Forest Products Laboratory, and, together with the Acme Steel Goods Co., has financed a series of tests on wooden shoe boxes. Specifications based on these tests will be prepared in the near future.

The above mentioned agencies and the Ordnance Department of the Army are now cooperating in a series of tests on the strapping of boxes. These tests are being made at the Forest Products Laboratory.

Tests and studies to determine the defects permissible in box lumber are contemplated.

The Bureau of Explosives has jurisdiction over containers for the shipment of explosives and other dangerous articles and prescribes tests and specifications.

The Container Club, an association of manufacturers of fiber and corrugated fiber boxes, is maintaining a Fellow at Mellon Institute to do research work on their materials and products.

The Four-One Association of Wirebound Box Manufacturers is very much interested in research studies on its boxes and the creation of standards. Its activities are centered in the Box Testing Laboratory of the Wirebounds Corporation at Rockaway, New Jersey.

The Glass Container Association of America has recently established a laboratory in Chicago for research, looking to improvements in the manufacture of glassware and the extension of its use. It is also very much interested in boxes.

The Associated Industries of Cooperage Manufacturers have under consideration a program for research study on barrels.

The American Railway Express Co. is greatly interested in standards for boxes.

The American Railroad Association has a committee on prevention of loss and damage which is extremely interested in efficient shipping containers.

The Chicago Mill and Lumber Co., and the Acme Steel Goods Co. now maintain laboratories for testing their products and serving their customers.

The General Electric Co. has installed facilities for testing the packing of lamps and has entered on a scientific study of shipping containers and packing for all their products.

Members of Committee D-10 are in close touch with all these agencies and several members of the committee participate directly in their activities.

Sub-Committee II on Nailed and Lock-Corner Containers has been especially active during the past year and has adopted a definite plan for their activities. They have drawn up and presented the Tentative General Specifications for Wooden Boxes, Nailed and Lock-Corner Construction, appended to this report.[1]

These General Specifications are intended to serve as a master specification or standard of construction for nailed and lock-corner boxes. It is expected that specifications for boxes for a specific commodity or groups of commodities will, as they are worked out through careful research, be made to conform closely to this general specification and that many of their requirements will be specified by reference to the general specifications. It will be necessary to add only such items as style and dimensions of box and minimum thicknesses of parts, and to enumerate such exceptions to the general specifications as may be found necessary. Many points must of necessity be common to all boxes of the classes under consideration, and brevity is gained by the scheme of specifying these in standards for boxes for a specific commodity by reference.

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[1] See p. 730.—ED.

The general specifications have the further value of providing a much needed standard as a guide to the construction of wooden boxes. The principal features of these specifications have been worked out from a large number of careful tests of boxes as such, and from very extensive data on the mechanical properties of woods as determined by the Forest Products Laboratory.

Committee D-10 recommends that the Society accept for publication as tentative, the Tentative General Specifications for Wooden Boxes, Nailed and Lock-Corner Construction, as appended to this report.[1]

The Tentative Specifications for Canned Foods Boxes, Nailed and Lock-Corner Construction (D 44 - 17 T)[2] were accepted as tentative by the Society in 1917. Committee D-10 recommends that these specifications be withdrawn and that there be substituted therefor the Tentative Specifications for Wooden Boxes, Nailed and Lock-Corner Construction, for the Shipment of Canned Foods, as appended.[3] This action is recommended in order to bring the canned foods box specifications into accord with the general program for nailed and lock-corner boxes as outlined above.

Committee D-10 further recommends the continuance for another year of the Tentative Specifications for Canned Foods Boxes, Wirebound Construction (D 45 - 17 T).[4]

The previously mentioned study of boxes for the shipment of shoes has furnished data for specifications. It is expected to put these in form and submit them to the Society at the annual meeting in 1921. It is hoped also that by the next annual meeting the tests on the strapping of boxes will be sufficiently advanced to permit inclusion in the general specifications of a rule for strapping and that studies of defects may provide a more definite paragraph on this subject. It is further expected that progress will be made towards specifications for additional commodities.

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[1] See p. 730.—ED.

[2] *Proceedings*, Am. Soc. Test. Mats., Vol. XIX, Part I, p. 680 (1919).

[3] See p. 727.—ED.

[4] See p. 728.

The letter ballot of the committee on the three recommendations is as follows:

Items.	Affirmative.	Negative.	Not Voting.
1. Acceptance of Tentative General Specifications for Wooden Boxes, Nailed and Lock-Corner Construction	20	0	9
2. Withdrawal of the present Tentative Specifications for Canned Foods Boxes, Nailed and Lock-Corner Construction, (D 44 - 17 T) and the substitution of Tentative Specifications for Wooden Boxes, Nailed and Lock-Corner Construction, for the Shipment of Canned Foods	19	0	10
3. Continuation of Tentative Specifications for Canned Foods Boxes, Wirebound Construction (D 45 - 17 T)	19	0	10

This report has been submitted to letter ballot of the committee, which consists of 29 members, of whom 22 have voted affirmatively, none negatively, and 7 have refrained from voting.

Respectfully submitted on behalf of the committee.

J. A. NEWLIN,
Chairman.

W. S. TOPPING,
Secretary.

EDITORIAL NOTE.

The proposed Tentative General Specifications for Wooden Boxes, Nailed and Lock-Corner Construction were accepted for publication as tentative and appear on pages 730–735.

The proposed Tentative Specifications for Wooden Boxes, Nailed and Lock-Corner Construction for the Shipment of Canned Foods were accepted for publication as tentative and appear on page 727. These replace the former Tentative Specifications for Canned Foods Boxes, Nailed and Lock-Corner Construction which were consequently withdrawn.

REPORT OF COMMITTEE D-11
ON
RUBBER PRODUCTS.

Committee D-11 presents for the consideration of the Society one new specification: namely, the Tentative Specifications for Adhesive Insulating Tape. This specification was presented at the last annual meeting of the Society and was referred back to the committee with instructions to confer with Committee D-9 on Electrical Insulating Materials and Committee E-2 on Electrical Standards. These instructions were complied with but no changes were suggested. The committee therefore recommends that these specifications, which are appended hereto,[1] be accepted for publication as tentative.

Committee D-11 also recommends advancing to standard the following tentative specifications; they have been published for one or more years as tentative but no suggestions for their revision have been received:

The Tentative Specifications for Leader Hose for Use with Pneumatic Tools (D 60 - 19 T);[2]

The Tentative Specifications for Steam Hose (D 54 - 18 T);[3]

The Tentative Specifications for Rubber Belting for Power Transmission (D 53 - 19 T).[4]

The Tentative Specifications for Insulated Wire and Cable (D 27 - 16 T)[5] are still in process of revision. The committee, therefore, desires that they be continued as tentative.

The letter ballot vote of the committee on these recommendations is as follows:

Items.	Affirmative.	Negative.	Not Voting.
I. SPECIFICATIONS PROPOSED AS TENTATIVE.			
Tentative Specifications for Adhesive Insulating Tape	19	1	12
II. TENTATIVE SPECIFICATIONS ADVANCED TO STANDARD.			
Tentative Specifications for Leader Hose for Use with Pneumatic Tools (D 60 - 19 T)	20	3	9
Tentative Specifications for Steam Hose (D 54 - 18 T)	21	3	8
Tentative Specifications for Rubber Belting for Power Transmission (D 53 - 19 T)	20	4	8

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[1] See p. 761.—ED.

[2] *Proceedings*, Am. Soc. Test. Mats., Vol. XIX, Part I, p. 724 (1919).

[3] *Ibid.*, p. 720.

[4] *Ibid.*, p. 715.

[5] See p. 736.

This report has been submitted to letter ballot of the committee, which consists of 32 members, of whom 23 have voted affirmatively, 1 negatively, and 8 have refrained from voting.

Respectfully submitted on behalf of the committee,

EDWARD A. BARRIER,
Chairman.

S. C. POTTS,
Secretary.

EDITORIAL NOTE.

The Tentative Specifications for Leader Hose for Use with Pneumatic Tools, the Tentative Specifications for Steam Hose, and the Tentative Specifications for Rubber Belting for Power Transmission, referred to in this report, were approved at the annual meeting and subsequently adopted by letter ballot of the Society on September 1, 1920, and appear in the supplementary pamphlet of A.S.T.M. Standards Adopted in 1920.

The proposed Tentative Specifications for Adhesive Insulating Tape were accepted for publication as tentative and appear on pages 761–763.

REPORT OF COMMITTEE D-13
ON
TEXTILE MATERIALS.

Committee D-13 on Textile Materials has held two meetings during the past year. The first was held at the Massachusetts Institute of Technology on December 5, 1919, at which 29 members and 20 guests were present. The present Tentative General Methods for Testing Cotton Fabrics (D 39 - 19 T)[1] were read but no revisions were suggested. W. O. Jelleme, Chairman of Sub-Committee III on Testing Machines, reported for the sub-committee and gave an account of an extended series of experiments made in the Brighton Mills Laboratory on types of jaw of testing machines, rate of loading and various machine characteristics.

A second meeting was held in the Engineering Societies Building in New York, on April 20, 1920, at which 17 members and 10 guests were present. The present Tentative General Methods for Testing Cotton Fabrics were endorsed by unanimous vote and the committee recommends that these methods be adopted by the Society as standard. The appended[2] Methods for Testing Textiles were proposed, in connection with which three papers were submitted by W. O. Jelleme. The text of these papers is appended in full.

This report has been submitted to letter ballot of the committee, which consists of 40 members, of whom 24 have voted affirmatively, 1 negatively, and 15 have refrained from voting.

Respectfully submitted on behalf of the committee,

G. B. Haven,
Chairman.

D. E. Douty,
Secretary.

Editorial Note.

The Tentative General Methods for Testing Cotton Fabrics were approved at the annual meeting and subsequently adopted as standard by letter ballot of the Society on September 1, 1920, and appear in the supplementary pamphlet of A.S.T.M. Standards Adopted in 1920.

The proposed Tentative Methods for Testing Textiles were accepted for publication as tentative and appear on pages 804–805.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XIX, Part I, p. 749 (1919).

[2] See p. 804.—Ed.

APPENDIX I.

VARIABLES AFFECTING THE INDICATED BREAKING STRENGTH OF COTTON FABRICS.

By W. O. Jelleme.

This analysis was made to enumerate, if possible, all of the variables affecting the indicated breaking strength of a fabric, in order to use this as a basis of experiment, to determine the effect of particular variables on the indicated break. By holding fixed all but one variable, and changing that by known amounts, the effect of that one may be obtained. The variables especially under consideration are:

1. The design of jaws;
2. Machine capacity;
3. Machine rate of load;
4. Speed of the pulling jaw.

The analysis is as follows:

I. Fabric Characteristics.

A. Unit Weight.—The breaking strength of a fabric, of course, varies with the amount of material which it contains and this is best measured by the weight per unit area of fabric.

B. Texture Constants.—It has been proven that there is some effect on the strength of a fabric due to the closeness with which the threads are laid and the amount of binding which there is of warp threads around filling threads and *vice versa.* The fundamentals of this are covered in Appendix IV to the report of Committee D-13 for 1916 under the title "Determination of Tensile Strength of Duck by the Strip Method" by E. D. Walen.[1]

C. Yarn Strength.—The fabric strength, of course, depends on the yarn strength modified by the effect of:

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XVI, Part I, p. 379 (1916).

1. Fiber strength. Yarn strength probably varies directly with fiber strength.

2. Fibers per cross section of yarn. This depends on the diameter of the fibers and since when a strand of yarn breaks, only a small percentage of them actually break and the rest of them slide apart, the more fibers there are in the cross section of the yarn, the more internal friction or grip there is in the yarn and consequently the greater the strength.

3. Friction of fibers or spirality of fibers. The internal friction in the yarn varies with the number of spirals per unit of length.

4. Fiber length. The longer the fibers in the yarn are, the more chance they have to grip with one another and consequently the greater the internal friction of the yarn.

5. Singles twist. Many experiments have been made to determine the effect of twist on yarn, and the points of maximum strength are fairly well known.

6. Ply twist. The twist in the ply also has an effect on the strength of the yarn, and points of maximum strength are to some extent known.

D. Elasticity.

1. Texture constants. The elasticity of a fabric certainly varies with the closeness of the threads.

2. Crimp. Crimp is in part a resultant of texture constants and with it, determines the amount of possible stretch due to the crimp of the yarns as they are laid in the fabric.

3. Yarn stretch. All items which affect yarn strength, also affect yarn stretch: See under "Yarn Strength" above.

II. SAMPLE CHARACTERISTICS.

There have been many previous discussions on the effect of the various sample characteristics on the strength of fabric, and these have been fairly well standardized by the work of Committee D-13.

A. Type.

1. Strip.
2. Grab.
    (*a*) 1 by 1 in.
    (*b*) 1 by 2 in., etc.

B. Size.

1. Width clamped.
2. Amount in depth of jaw.

C. Condition. (Regain.)

III. MACHINE CHARACTERISTICS.

A. Capacity.—Capacity has an effect on the indicated breaking strength of the fabric only as it in turn affects the machine rate of load or the fabric rate of load.

B. Machine Rate of Load.[1]

1. Dead pull.
2. Inertia and acceleration.

C. Design of Jaws.—Some experiments have been conducted by the Bureau of Standards and it has been found that all items listed below have some effect on the breaking strength:

1. Width.
2. Depth.
3. Form.
4. Facing used.
5. Pressure.

D. Initial Distance between Jaws.—This also has been investigated previously and with a result of setting the standard as at present for 3 in. initial distance.

E. Speed of pulling Jaws.—See standard speeds in Methods for Testing Cotton Fabrics (D 39 – 20).[2]

IV. OPERATOR CHARACTERISTICS.

A. Speed.

1. Time from oven to break on bone-dry tests. This has been found to affect the amount of regain which a sample absorbs during the test. A limit has been set at 20 seconds as the proper maximum time for tests which are to be considered "bone dry." Tests are being regularly run now within this limit and an average of 15 seconds maximum in some laboratories has been obtained. Under this condition it is found that about 0.25 to 1 per cent regain is absorbed by the samples during the test.

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[1] For the effect of rate of load, see Appendix II.

[2] A.S.T.M. Standards Adopted in 1920, p. 116.

B. Precision.

1. Alignment of sample to jaws. If the line of pull is not parallel to the center line of the sample, the action will be tearing rather than direct breaking and a lower indicated break will result.

2. Centering of sample to jaws. The same applies to this as to alignment.

3. Pressure of jaw. In the screw clamping type of jaw, the pressure with which the jaw is tightened is known to have some effect on the indicated break. Further tests may reveal exactly what this is. In general, it may be said that a cam clamping action gives more uniform results and tends to eliminate one of the variables of the operator.

APPENDIX II.

MACHINE RATE-OF-LOAD AS AFFECTING BREAKING STRENGTH SHOWN BY FABRIC TESTING MACHINES.

By W. O. Jelleme.

The various fundamental types of fabric testing machines are ably discussed in the report of Sub-Committee III on Testing Machines in Appendix III to the report of Committee D-13 for 1918.[1] Considering the fact that the machines most commonly used and most practical for commercial testing are those of the constant increment-of-pull type, this type alone is considered in this paper. The object of this paper is to show the effect of the rate of load on the breaking strength indicated for any particular fabric, according to the design of the various machines on the market.

In this paper, the term "machine rate-of-load" will be taken to mean the rate of application of the load in terms of pounds of indicated load per inch of travel of the head jaw. Assuming a material having a zero stretch, the head jaw will move just as fast as the pulling jaw; but in all cases in which there is a stretch in the material tested, the head jaw will move slower. That is, machine rate-of-load has nothing whatever to do with the fabric but simply with the rate at which the load is applied by movements of the machine itself, the load being considered in terms of the distance traveled by the head or pulled jaw. Supposing a fabric to have no stretch, this would also be the rate at which the load is applied, the rate in this case being in terms of increments of elapsed time.

"Fabric rate-of-load" is taken to mean the rate, in terms of pounds per unit of elapsed time, at which the load is applied to any given fabric.

In these definitions the machine is considered to show an indicated load at rest. The inertia of the moving parts is not taken into account. The inertia will have an effect on the break shown by any machine and will be governed by the distance of the center of gravity of the pendulum from the pivot and by the mass of the pendulum.

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XVIII, Part I, p. 370 (1918).

Considering the testing machine at rest, the variables affecting the load shown on the dial for any position of the pendulum were analyzed.

Using the following notation,

P = Effective pull on jaw,
T = Travel of head jaw,
R = Radius from pivot to center of gravity of pendulum,
k = factor less than unity, introduced to allow for friction losses.
W = Effective weight of pendulum,
D = Diameter of chain drum,
C = Thickness of chain,
θ = Angle of travel of pendulum from vertical in degrees,

from Fig. 1, we have

$$\text{Moment of } W = W R \sin \theta \ldots\ldots\ldots\ldots (1)$$

$$\text{Moment of } P = P \left(\frac{D}{2} + \frac{C}{2}\right) \ldots\ldots\ldots\ldots (2)$$

$$W R \sin \theta = P \left(\frac{D + C}{2}\right) \ldots\ldots\ldots\ldots (3)$$

$$P = W \frac{R \sin \theta}{\frac{D + C}{2}} \ldots\ldots\ldots\ldots (4)$$

Eq. 4 makes no allowance for friction losses. Taking these into consideration, the formula is stated:

$$P = k W \frac{R \sin \theta}{\frac{D + C}{2}} \ldots\ldots\ldots\ldots (5)$$

Also,

$$T = \frac{\theta}{360} \pi (D + C) \ldots\ldots\ldots\ldots (6)$$

Observations were then taken on the machines studied, of the angle of the pendulum from the vertical and the distance traveled by the head jaw for various positions of the pendulum. Machines studied were the Scott Combination Horizontal 800-lb. and 400-lb. capacities, the Scott Combination Vertical 300-lb. and 75-lb. capacities, and the Schopper 500-kg. Vertical machines. (See Table I.)

Using the observed values of T as a basis, a calculated value of θ was obtained from Eq. 6. These calculated values were then checked against the observed values. In Eq. 5, the values k, R, D, C, and W are constant for any machine. This equation may therefore be resolved into

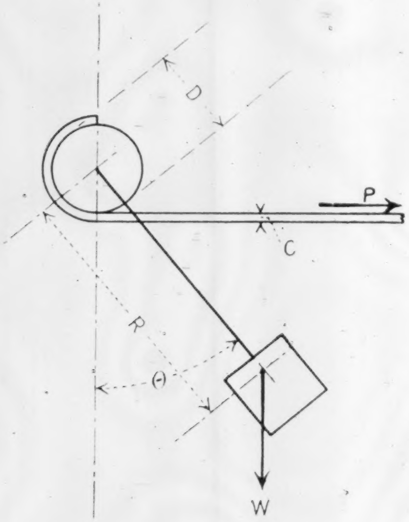

FIG. 1.—Diagram of Device for Measuring Load in Fabric Testing Machine.

$$P = K \sin \theta \qquad (7)$$

the value of K for each machine was calculated from the calculated values of the angles and the values for K so obtained averaged as shown in Table I.

TABLE I.—MACHINE DATA.

Observed Values.				θ, deg., from Eq. 6	K, from $P = K \sin \theta$	P,		θ, deg., from $P = K \sin \theta$ (using average value of K)	T, from $T = 0.541\ \theta$	
P,		θ, deg.	T, mm.							
lb.	kg.					lb.,	kg.		mm.	in.
SCOTT 300-LB. VERTICAL. $D = 55$ mm. $C = 7$ mm. $T = 0.541\ \theta$										
100		20	10	18.48	315.5	50		8.9751	4.86	0.191
200		40	21	38.81	319.1	100		18.1803	9.84	0.387
250		52	27.5	50.83	322.5	150		27.9055	15.10	0.594
300		68.5	36.5	67.46	324.8	200		38.6105	20.89	0.822
						250		51.2650	27.73	1.092
					Average 320.5	300		69.3958	37.54	1.478
SCOTT 75-LB. VERTICAL. $D = 55$ mm. $C = 7$ mm. $T = 0.541\ \theta$										
						12.5		8.9751	4.86	0.191
						25		18.1803	9.84	0.387
						37.5		27.9055	15.10	0.594
						50		38.6105	20.89	0.822
						62.5		51.2650	27.73	1.092
						75		69.3958	37.54	1.478
SCHOPPER 500-KG. VERTICAL. $D = 288$ mm. $C = 12$ mm. $T = 2.618\ \theta$										
	100	10	27	10.32	558.2		100	10.2478	26.83	1.056
	250	27	68	25.98	570.7		200	20.8431	54.57	2.148
	375	43	109.7	41.91	561.4		300	32.2567	84.45	3.325
	450	51.5	140.7	53.75	558.0		400	45.3667	118.77	4.676
							450	53.1850	139.24	5.482
					Average 562.1		500	62.8138	161.45	6.474
SCOTT 800-LB. HORIZONTAL. $D = 85.7$ mm. $C = 14$ mm. $T = 0.87004\ \theta$										
401		24	21.1	24.25	976.3	100		5.8358	5.07	0.200
490		30	26.0	29.88	983.7	200		11.7333	10.21	0.402
552		33.5	29.6	34.02	986.7	300		17.7603	15.45	0.608
613		38.5	33.4	38.39	987.1	400		23.9988	20.88	0.822
774		51.5	....	....		500		30.5568	26.59	1.047
						600		37.5948	32.71	1.288
					Average 983.5	700		45.3778	39.48	1.554
						800		54.4317	47.36	1.865
SCOTT 400-LB. HORIZONTAL.										
						50		5.8358	5.07	0.200
						100		11.7333	10.21	0.402
						150		17.7603	15.45	0.608
						200		23.9988	20.88	0.822
						250		30.5568	26.59	1.047
						300		37.5948	32.71	1.288
						350		45.3778	39.48	1.554
						400		54.4317	47.36	1.865
RHIELE 600-LB. SPRING.										

600 lb. on dial = 360 deg. Dial pointer pinion 10 T. Rack moving with head jaw. 25 teeth in 3 in. $\frac{10}{25} \times 3 = 1.2$ in. per 600 lb.

The variation in the value of K for the different observations on each machine is due to the difficulty of correctly measuring the angle of the center line of the pendulum from the vertical. Whatever error there may be in this respect is minimized by averaging the values of K and the error is small compared to the difference between rates of load of different types of machines as later deduced.

The next step was to calculate values of the angle θ for graduations of P, first in degrees, minutes and seconds; then in degrees and decimals of degrees and from the latter value to calculate a value of T in millimeters and inches. These are shown in Table I.

Considering a standard speed of 12 in. per minute of the pulling jaw (assuming for the machine rate-of-load that the head jaw moves as fast as the pulling jaw) 12 in. per minute equals 1 in. per 5 seconds. This double scale has been used in plotting the curves showing rate of loading (Fig. 2).

The line for the Riehle machine was drawn as a straight line on the assumption that the springs are accurate throughout the entire range and give a uniform rate of load. There are slight divergencies from this on account of inaccuracy in the springs, but in general the straight line is correct.

The various load curves given in Fig. 2 show very clearly what a wide difference there is in machines which are supposed to do the same work and give the same results. Assuming the kind of sample, the kind of jaws and the speed of the pulling jaws to be the same, the machine characteristics which affect the resultant indicated strength are probably as follows:

1. The distance of the center of gravity of the pendulum from the pivot.
2. The acceleration of the pendulum during the test.
3. The weight of the carriage, head jaw and all connecting parts.
4. The time which it takes to break the sample.

The first three characteristics are due to the inertia and acceleration of the moving parts of the machine; the last one depends on the rate at which the load is applied by the machine and the curves drawn show the difference between the several machines in this respect. It is useless to suppose that the same test results can be secured, for example, on the Riehle or Scott 800-lb. machines as on the Scott 75-lb. machine. If the machine rates-of-load were the same, it is the writer's belief that the

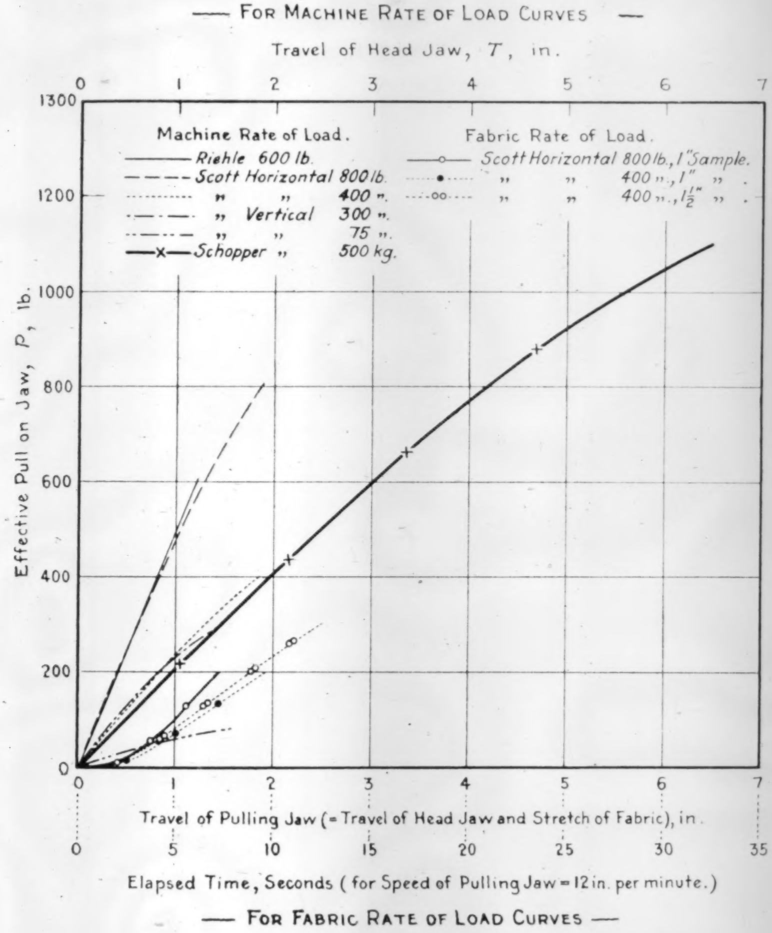

FIG. 2.—Machine and Fabric Rate-of-Loading Curves.

same test result could be shown no matter what the maximum capacity of the machine might be.

The machine rate-of-load curve also shows that there is a point at which the rate of load decreases very materially. This is true in all pendulum machines because the rate-of-load curve is in reality a sine curve reaching at 90 deg. swing of the pendulum a zero increment of load. It is still to be definitely proven at just what point the accuracy of the machine is impaired and the deceleration in the rate of load becomes such as to put the fabric being tested under strain for such an added length of time as to affect the resultant break; but from the figures in the tables and the form of the curve, it can be deduced that this point of change is probably at about 30 deg. or a little less of swing of the pendulum from the vertical.

To determine just what effect the rate of load has on the test, a device for automatically recording a stress-strain diagram, which had been developed for the Scott 800-400 Horizontal Machine, was used. All variables except rate-of-load were eliminated by using the same machine, jaws, initial distance between jaws, speed of pulling jaw, bone-dry condition of fabric, and the same warp threads in the samples for all tests. The last item eliminates as far as may be done any variation in the cotton. Four sets of tests were made, all diagrams for each set being run on the same sheet, and from the composite thus made, the average stress-deformation curve for the fabric under each condition of test was obtained.

TABLE II.—STRESS-DEFORMATION DIAGRAM ORDINATES, SAME ENDS BROKEN.

Indicated Load P, lb.	Deformations.							
	800-lb. Machine, 1-in. Sample.		800-lb. Machine, $1\frac{1}{2}$-in. Sample.		400-lb. Machine, 1-in. Sample.		400-lb. Machine, $1\frac{1}{2}$-in. Sample.	
	cm.	in.	cm.	in.	cm.	in.	cm.	in.
10	0.89	0.350	0.68	0.268	0.75	0.295	0.71	0.280
20	1.16	0.457	0.96	0.378	1.09	0.429	0.99	0.390
40	1.51	0.594	1.29	0.508	1.41	0.555	1.28	0.504
60	....	....	....	....	1.63	0.642	1.49	0.587
80	1.84	0.724	1.63	0.642	1.81	0.713	1.66	0.654
100	....	....	....	....	1.95	0.768	1.81	0.713
120	2.11	0.830	1.88	0.740	2.10	0.827	1.94	0.764
140	....	....	....	....	2.27	0.894	2.08	0.819
160	2.38	0.937	2.10	0.827	2.43	0.957	2.21*	0.870
180	....	....	....	....	2.60	1.024	2.35	0.925
200	2.71	1.067	2.31	0.909	2.80	1.102	2.48	0.976
220	....	....	....	....	....	....	2.61	1.028
240	....	....	2.55	1.004	....	....	2.74	1.079
260	....	....	....	....	....	....	2.85	1.122
280	....	....	2.83	1.114	....	....	3.03	1.193
300	....	....	2.93	1.153	....	....	3.15	1.240

The stress-deformation diagrams, Fig. 3, show the results and Table II gives the values of the ordinates and abscissae. The tests are for 1 and $1\frac{1}{2}$-in. samples on the 400-800 lb. capacities. The threads used in the two 1-in. tests are exactly the same, and also those in the two $1\frac{1}{2}$-in. tests; and the $1\frac{1}{2}$-in. test samples were cut from the same piece of fabric so as to contain the same warp threads and in addition those needed to make the extra width.

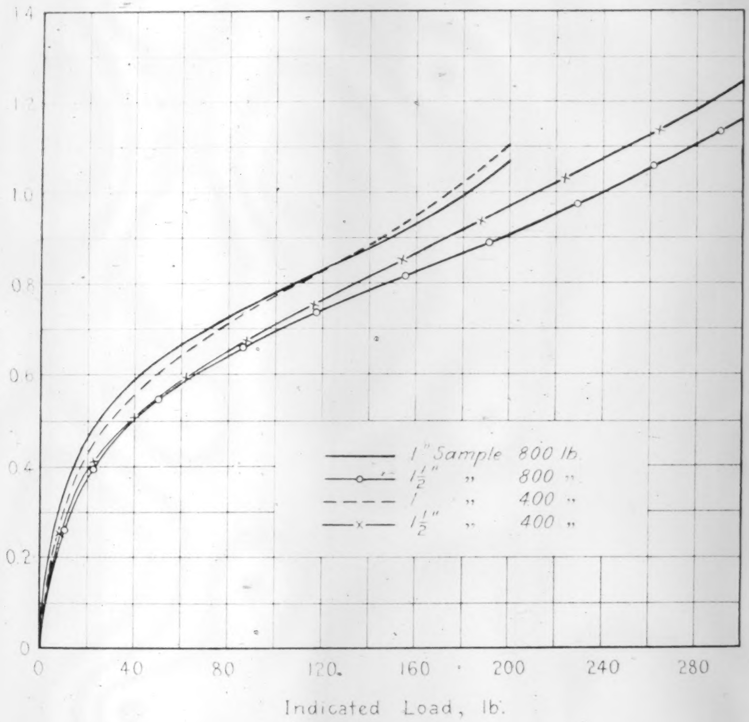

FIG. 3.—Stress-Strain Diagram, Tire Builder Fabric.

Scott 800–400-lb. Horizontal. 11¼ oz. Tire Builder Fabric, Bone Dry. Pulling Jaw Speed, 12 in. per min., Initial Distance, 3 in.

An examination of the curves reveals the following characteristics:

1. The slower rate of load (400-lb. capacity) gives a higher stretch.

2. The forms of the two curves on 1-in. samples hold the same relationship one to the other as those on $1\frac{1}{2}$-in. samples. This indicates that the rate of load is responsible for the difference.

3. The curves from the tests on the 400-lb. machine show an increase in the rate of stretch at a load of about 200 lb. This results in increased variations for the slower machine-rate-of-load, for an increasing rate of stretch decreases the fabric rate of load still more. Of course, there is some departure from a uniform rate of load in the 800-lb. machine, since both rates of load are sine curves, but the departure in the 400-lb. machine comes at much lower loads.

To show what strains are actually present in the fabric during the test, the stress-strain diagram was plotted against the machine rate-of-load curve as a base, giving the three fabric rate-of-load curves shown. The detailed method of plotting fabric rate-of-load curves is as follows: The y-coordinate equals the indicated pull or breaking strength as obtained on the stress-strain diagram. The x-coordinate equals the distance traveled by the head jaw, as shown by the machine rate-of-load curves, plus the stretch of the fabric shown by the stress-strain diagram. The total of these two equals in any case the distance traveled by the pulling jaw, which may be considered either in distance or in time.

These fabric rate-of-load curves bear out the remarks above in regard to machine rate-of-load and the effect of machine rate-of-load as shown in the stress-strain diagram, and that an increase in the rate of stretch will still further, when occurring at a decreasing machine rate-of-load, decrease the fabric rate-of-load.

It would, therefore, seem wise to specify all testing machines on the following points:

1. Maximum capacity of machine.

2. Rate-of-load of machine. This should be uniform in all machines. It probably makes very little difference as to what particular rate of load is used as long as all machines are built with the same rate of load.

3. The maximum angle of swing of the pendulum. This can at present be stated as about 35 deg., but more graphs of tests may determine a variation above or below this point as the base limit.

APPENDIX III.

EFFECT OF JAWS ON FABRIC STRENGTH.[1]

By J. H. Dunlap, A. E. Jury, and W. O. Jelleme.

The object of this study was to determine the effect of the design of jaw on the indicated breaking strength of fabrics and to determine a type of jaw that could be recommended for adoption as standard, giving a minimum of variation in results and of such construction as to have the smallest possible number of variables.

In view of existing conditions, a large number of variables may effect the indicated breaking strength of a fabric, of which the design of the jaw is only one.[2] In order to determine the effect of jaw design, all of the other variables must be held constant as nearly as possible. In order to do this, all variables of fabric characteristics were reduced to a minimum by using the same piece of fabric in each series of tests and laying out the test specimens so that identical warp threads were used in each set of samples taken across the width of the piece of cloth for the various sets of jaws.

Two series of tests were made covering two methods: one, the A.S.T.M. Strip Test Method, in which the samples were raveled to 23 threads, and the other, the 2 by 1-in. Grab Test Method. This test, therefore, shows also a comparison between strip and grab test methods.

All testing was done in bone-dry condition, breaks being obtained in from 15 to 20 seconds after the removal of samples from the oven.

All machine characteristics were reduced to a minimum of variation by making all tests on the same type of machine: namely, the Scott Horizontal Machine, 800 lb. capacity, with an initial distance of 3 in. between jaws and with a speed of pulling jaw of 12 in. per minute. The variables of speed and operator characteristics were eliminated by carefully watching the time taken to obtain the break after the removal of the sample from the oven. The above arrangement of tests leaves as variables only the design of the jaw (the type of clamp and the form of the anvil as to width, depth, shape and facing) and the precision element of the operator characteristics, which would be very difficult to eliminate in any case and which must be considered in judging the results of one laboratory against another.

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[1] Study made cooperatively by United States Rubber Co., Brighton Mills, and Goodyear Tire and Rubber Co.

[2] See Appendix I, "Variables Affecting the Indicated Breaking Strength of Cotton Fabrics" by W. O. Jelleme.

The apparatus used in the test may be summarized as follows:

Fabric, $17\frac{1}{4}$-oz. combed Egyptian tire builder.

Testing Machine, Scott Horizontal testing machine, 800 lb. capacity.

Speed of Pulling Jaw, 12 in. per minute.

Initial Distance Between Jaws, 3 in.

Jaws:

JAW NO.	TYPE OF CLAMP.	TYPE OF ANVIL.	ANVIL DIMENSIONS, IN.
1	Screw	Flat	2 x 1
2	Cam	Flat	2 x $1\frac{3}{8}$
3	Eccentric	Flat	2 x 1
4	Cam	Brighton Corrugated	2 x $1\frac{3}{8}$
5	Cam	Scott Corrugated	$2\frac{1}{2}$ x $1\frac{3}{8}$.

All testing was done on the various types of jaws with strip tests and also with grab tests using a 1-in. upper jaw on the pulling end.

All results of the tests are shown in Table I, giving the averages and deviations on each type of jaw and test in the different laboratories and in Figs. 1 to 6, all of which show the number of tests at each breaking strength.

Figs. 1, 2, 4, and 5 show the results obtained in the separate laboratories and Figs. 3 and 6 show the combined results of two laboratories. No charts are shown for the results obtained by Goodyear Tire and Rubber Co., owing to the fact that all tests scheduled could not be made, due to the difficulty in fitting the various types of jaws to the testing machine. Those tests which were made are shown in the tables and indicate an agreement, as far as they go, with the other series of tests. The charts are plotted with a vertical scale of breaking strength. Each of the horizontal lines shows the number of breaks occurring at any particular point, the relative lengths of the lines indicating the number of breaks. The shortest length shown indicates one break.

The following conclusions are drawn:

1. The variation in the strip test method is much less than in the grab test method.

TABLE I.—RESULTS OF TESTS MADE BY VARIOUS LABORATORIES.

Jaw No.	Average of 100 Breaks, lb.	Percentage Deviation from Average.								
		20	15	10	5	0	5	10	15	20
BRIGHTON MILLS. STRIP TEST.										
1	186	3	5	10	12	34	27	7	2	...
2	180	0	3	7	22	39	29	0	0	...
3	175	1	2	11	21	25	28	12	0	...
4	187	0	0	6	20	49	25	0	0	...
5	180	0	0	6	22	45	23	4	0	...
BRIGHTON MILLS. GRAB TEST.										
1	263	0	2	10	18	39	21	10	0	...
2	248	0	0	6	29	40	16	9	0	...
3	293	1	2	4	18	41	25	9	0	...
4	252	0	1	5	22	36	25	11	0	...
5	269	0	2	5	23	42	16	11	1	...
UNITED STATES RUBBER CO. STRIP TEST.										
1	182	...	1	11	24	31	25	8	...	...
2	172	...	4	4	23	40	16	11	2	...
3	177	...	3	7	30	30	25	5	...	...
4	174	3	5	4	17	22	33	11	5	...
5	175	...	...	5	32	29	27	4	3	...
UNITED STATES RUBBER CO. GRAB TEST.										
1	256	...	1	5	23	36	29	6	...	...
2	254	...	3	10	18	33	26	8	1	...
3	285	...	3	9	28	31	22	7	...	...
4	242	1	3	9	16	38	22	11	...	...
5	245	...	2	7	15	39	25	8	4	...
GOODYEAR TIRE AND RUBBER CO. STRIP TEST.										
1	182		...	3	23	51	22	1	...	...
5	181.8	1	2	3	21	41	28	5	...	...
GOODYEAR TIRE AND RUBBER CO. GRAB TEST.										
1	267	...	...	8	17	46	23	7	...	...
5	244	...	3	11	21	43	24	6	2	...

2. The change of operator has a very large influence on breaks. The use of the corrugated anvils with the cam clamping jaw was a new feature to the operators of the United States Rubber Co., and whereas the best results of any were obtained on Jaw No. 4 in the Brighton Mills' Laboratory, this jaw did not show

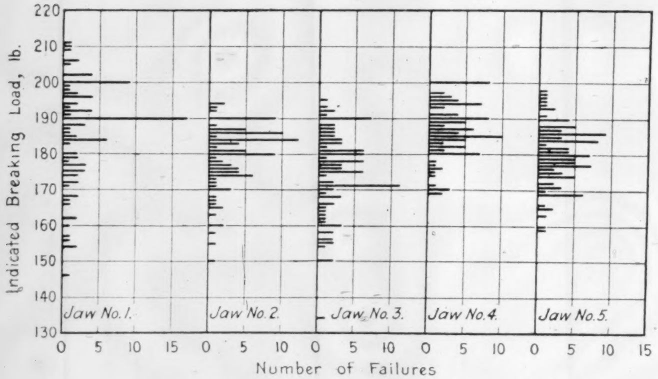

FIG. 1.—Strip Tests, Brighton Mills.

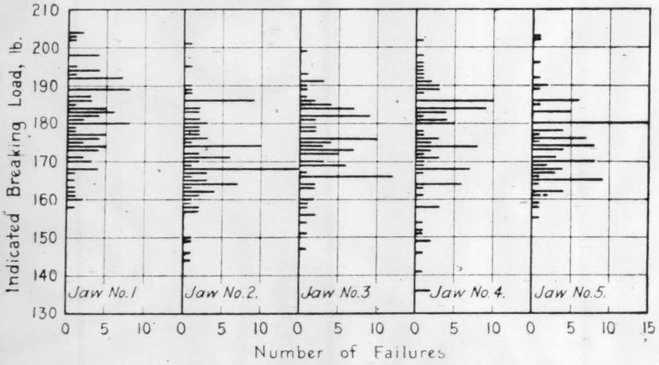

FIG. 2.—Strip Tests, United States Rubber Co.

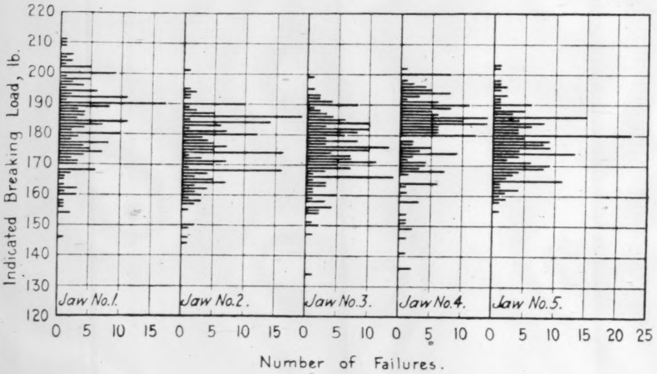

FIG. 3.—Accumulative Strip Tests.

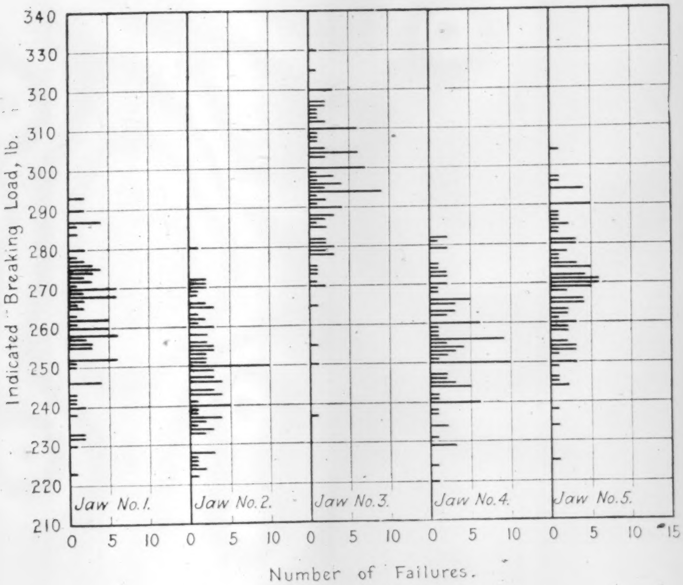

FIG. 4.—Grab Tests, Brighton Mills.

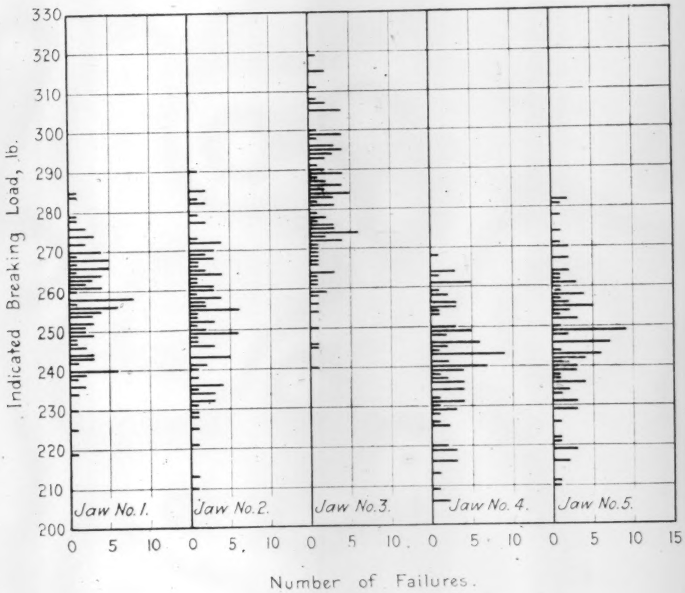

FIG. 5.—Grab Tests, United States Rubber Co.

good results in the other laboratories, nor does it show a good result in the accumulative chart, Fig. 3.

3. The screw method of clamping, as in Jaw No. 1, introduces a large variation which shows in each one of the charts. Operators accustomed to this type of clamp produce better results than those not accustomed to it, but the results are not equal to those obtained by some of the other forms of clamp.

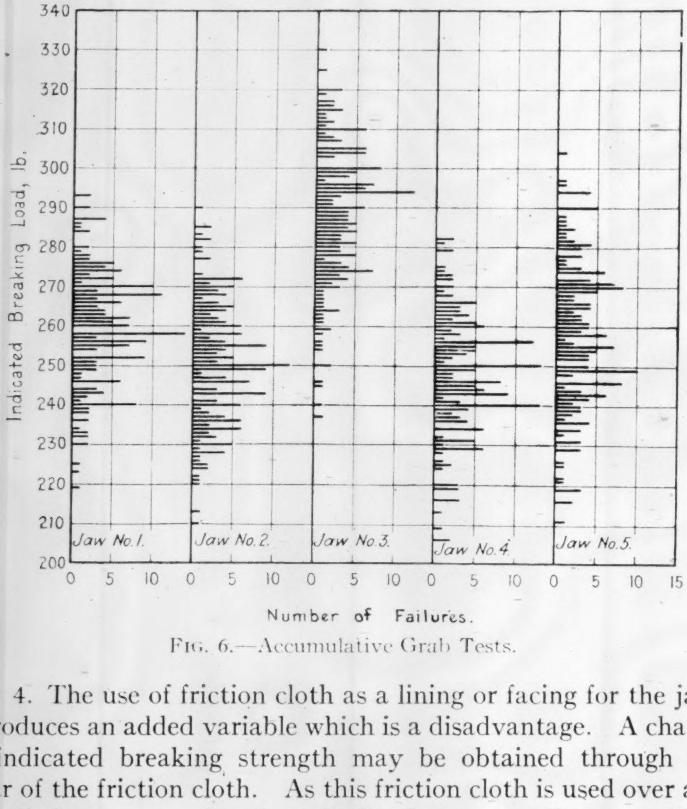

FIG. 6.—Accumulative Grab Tests.

4. The use of friction cloth as a lining or facing for the jaws introduces an added variable which is a disadvantage. A change in indicated breaking strength may be obtained through the wear of the friction cloth. As this friction cloth is used over and over, it is compressed and gradually shows a smaller gage thickness. Hence the jaw requiring this as a facing is not good.

5. It is concluded that best results are obtained by a cam operated clamp and that No. 2 jaw, as shown by Fig. 3, shows the best result in this test. It is, therefore, recommended that the standard jaw be one operated by an eccentric cam clamping device and that anvils have plane surfaces without lining.

REPORT OF COMMITTEE E-4

ON

MAGNIFICATION SCALES FOR MICROGRAPHS.

Committee E-4 desires to offer the following amendments to the Tentative Definitions and Rules governing the Preparation of Micrographs of Metals and Alloys (E 2 - 19 T):[1]

Section 4 (a).—Change from its present form, namely:

> "For magnifications from 20 to 50: A lens of the microplanar or microtessar type (*e. g.*, approximately 35-mm. focal length); no ocular is required.",

to read as follows:

> "For magnifications from 20 to 50: A photographic lense of approximately 35-mm. focal length, to be used without ocular."

Section 5 (a).—Change to read as follows by the addition of the italicized words and the omission of the words in brackets:

> "All objectives should be corrected for [uncovered objects] ***use without cover glasses.***"

The first change is made to eliminate the recommendation of patented or trade-marked articles. The second is made to make plain the fact that this statement refers only to cover glasses and not to immersion objectives.

As no comment or criticism of the Tentative Definitions and Rules has come to the attention of the committee since the last revision, they are recommended to the Society for adoption as standard.

It is the desire of the committee that if these Rules are accepted as standard the Secretary of the Society should furnish copies to other scientific societies in this country and abroad for their consideration.

The Executive Committee has acted favorably upon the recommendation of Committee E-4 that its name be changed from "Committee on Magnification Scales for Micrographs" to

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[1] *Proceedings*, Am. Soc. Test. Mats., Vol. XIX, Part I, p. 768 (1919).

"Committee on Metallography." The committee is forming a sub-committee on "Preparation of Metallographic Specimens" with Wm. Campbell as Chairman. Committee E-4 desires to cooperate with other committees of the Society interested in metallographic problems.

The committee recommends to the Executive Committee the forming of a Standing Committee on Pyrometry. Committee E-4 is very much interested in this matter but as at present constituted believes the subject too broad for its consideration.

This report has been submitted to letter ballot of the committee, which consists of 16 members, of whom 15 have voted affirmatively, none negatively, and 1 has refrained from voting.

Respectfully submitted on behalf of the committee,

W. H. BASSETT,
Chairman.

EDITORIAL NOTE.

The proposed revision of the Tentative Definitions and Rules Governing the Preparation of Micrographs of Metals and Alloys was accepted. The tentative specifications, as thus revised, were approved at the annual meeting and subsequently adopted by letter ballot of the Society on September 1, 1920, and appear in the supplementary pamphlet' of A.S.T.M. Standards Adopted in 1920.

REPORT OF COMMITTEE E-5
ON
STANDING COMMITTEES.

THIS COMMITTEE CONSISTS OF THE CHAIRMEN OF ALL STANDING COMMITTEES, OR REPRESENTATIVES DESIGNATED BY THE RESPECTIVE CHAIRMEN. THE DUTIES OF THIS COMMITTEE ARE THE FORMULATION OF (*a*) REGULATIONS GOVERNING STANDING COMMITTEES; (*b*) REGULATIONS GOVERNING THE FORM BUT NOT THE SUBSTANCE OF STANDARDS, AND (*c*) THE CLASSIFICATION OF STANDARDS.

Since the last annual meeting of the Society, Committee E-5 has held one meeting on December 11, 1919. The meeting was well attended, 22 of the 33 members being present or represented. The committee begs to report as follows upon its activities during the year:

Expression of Measurements in A.S.T.M. Standards in Both English and Metric Units.—In October of last year, the Executive Committee referred to Committee E-5 for consideration and advice the question of expressing measurements in A.S.T.M. Standards in both English and metric units. The subject was fully discussed by Committee E-5 at its meeting referred to above, the consensus of opinion being that it is desirable to express measurements in A.S.T.M. Standards in both English and metric units. A revision of Section 19 on "Units of Measurements" of the Regulations Governing the Form but not the Substance of Standards[1] was adopted by the committee and referred to the Executive Committee for its consideration. The standing committees of the Society were advised of this change; and in pursuance of a request from one of these committees, the Executive Committee has directed Committee E-5 to conduct a comprehensive hearing which all members of the standing committees who are interested in this important subject will be invited to attend. It was not found possible to arrange for this hearing prior to the annual meeting, and it will accordingly be held as soon thereafter as seems feasible.

Standing Committee on Nomenclature.—During the year there was referred to Committee E-5 by the Executive Committee a request from Committee C-11 on Gypsum that an official basis of cooperation be established on the subject of nomenclature between certain committees of the Society who were concerned with the Tentative Definitions of Terms Relating to the Gypsum Industry, which have been prepared by Committee C-11. This subject was carefully considered at the meeting of Committee E-5, in connection with the following paragraphs in the Regulations Governing Standing Committees:[1]

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[1] 1919 A.S.T.M. Membership List, p. 240.

> "It is recommended that the various standing committees should formulate proposed standard definitions of terms in matters falling in their respective fields, and that in the case of terms which come within the province of two or more committees, such definitions be formulated by joint action, through sub-committees, on the part of the committees concerned. Such proposed standard definitions of terms will be subject to adoption by the Society under the provisions of the by-laws and the Regulations Governing Standing Committees.
>
> "An alphabetic glossary of standard definitions of terms will be published in the Book of A.S.T.M. Standards as soon as their number appears to warrant such action."

Since the above paragraphs in the Regulations were written, the activities of the standing committees on the subjects of nomenclature and definitions have grown materially. Committee E-5 therefore determined to recommend to the Executive Committee that a Standing Committee on Nomenclature and Definitions be created to consist of a representative from each standing committee of the Society; and furthermore, since a committee so constituted would be largely administrative in its functions, that the Secretary of the Society should be *ex-officio* the secretary of the committee.

The Executive Committee approved this recommendation and authorized the creation of a Standing Committee on Nomenclature and Definitions, to be constituted as recommended by Committee E-5 and to perform the following broad functions:

> "To receive the recommendations concerning nomenclature and definitions from the various committees of the Society and either to approve them or refer them back to the originating committee with such suggestions and modifications as seem necessary; to act as a correlating com-

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[1] 1919 A.S.T.M. Membership List, p. 236.

> mittee in all work on this subject and to furnish a means for committees working on allied subjects to work together on matters of definitions."

The Executive Committee has directed Committee E-5 to prepare regulations under which the proposed new committee shall function. These regulations have been prepared and are now under consideration by Committee E-5. It is expected to arrange for the formal organization of the new committee soon after the annual meeting.

Proposed Standing Committee on Sand.—The Executive Committee sought the advice of Committee E-5 in the consideration of a certain resolution that had been referred to the Executive Committee at the last annual meeting, in which it was proposed to create a Standing Committee on Sand to be composed of one representative from each committee of the Society dealing with sand. This subject was completely discussed at the meeting of Committee E-5, with the result that the committee recommended to the Executive Committee that it is undesirable to create such a separate standing committee, and pointed out that the present machinery of the Society provides a satisfactory means of discussing matters of common interest to several standing committees, through the formation of a suitable conference committee. Committee E-5 understands that this recommendation was subsequently adopted by the Executive Committee.

Meetings of A.S.T.M. Committees and Sub-Committees.—Committee E-5 has given some consideration during the year to the desirability of providing that a schedule of meetings of the standing committees of the Society shall be maintained in the Secretary-Treasurer's office, and arrangements made to hold committee meetings at the Society's headquarters whenever possible. The committee at its meeting on December 11 therefore adopted the following resolution:

> "That the standing committees of the Society be requested to file with the Secretary-Treasurer a schedule of their regular meetings (and of sub-committee meetings), and to advise the Secretary-Treasurer in advance of calling a regular or special meeting in order that such meetings

> may, if possible, be scheduled at the Society's headquarters, or that advice may be given in the case of conflicts with other committees."

This resolution met with the approval of the Executive Committee, and the preparation of a schedule of meetings is now being undertaken by the Secretary-Treasurer of the Society.

This report has been submitted to letter ballot of the committee, which consists of 33 members, of whom 26 have voted affirmatively, none negatively, and 7 have refrained from voting.

Respectfully submitted on behalf of the committee,

C. L. WARWICK,
Chairman.

REPORT OF COMMITTEE E-6
ON
PAPERS AND PUBLICATIONS.

Committee E-6 has held one meeting during the year, on February 20, 1920, at which the program for the annual meeting was planned so far as possible at that time. Since then its functions relative to acceptance of papers and arrangement of the program have been discharged by the Advisory Committee and by the members of the committee individually. The committee has also received advice on the acceptance of papers from members of the Society not connected with the committee, for which the committee desires to record its appreciative acknowledgment.

Every effort has been made to make the program for this meeting of general interest to the members. The committee has been successful, it believes, in arranging well-balanced sessions, especially those relating to steel, testing apparatus, preservative coatings, road materials and concrete. The program contains 27 reports and 29 papers, the latter representing the final selections from a total of about 45 offers. Several papers were offered too late for consideration by the committee, and four papers that had been previously offered and tentatively accepted and announced on the provisional program, have been withdrawn by the authors.

With respect to technical papers, the problem of the committee was to select those most acceptable and of greatest interest to the members from among the many offers received. Moreover, the committee had been directed by the Executive Committee to limit in a general way the number and length of papers in view of the tremendously increased cost of printing. By careful editing and by engaging the cooperation of authors in writing their papers in as brief and concise form as possible, the committee has been able to keep the papers within reasonable limits as to volume without detracting from their value.

With respect to committee reports, it may be said in a general way that the past year has been one of the most active in the history of A.S.T.M. committee work. For example, the total number of pages of reports preprinted for the last annual meeting was 385; this year the number is 546, or an increase of nearly fifty per cent. The reports, moreover, are replete with valuable information and contain many proposed new standards. No better indication of the healthy vitality of our committees could be asked.

All of the 56 reports and papers announced on the program have been preprinted for use at the meeting. Twenty-four committee reports and 18 papers, aggregating 647 pages, were mailed in advance to the members in three instalments on April 30, May 29 and June 12. The preprints aggregate 961 pages as compared with 873 pages last year. The comparative data since 1913, when preprinting was first undertaken on an extensive scale, are given in Table I.

TABLE I.—COMPARATIVE DATA FOR PREPRINTS.

Year.	Preprints.			On Program, but not Preprinted, pages.
	Distributed in Advance, pages.	Not Distributed in Advance, pages.	Total pages.	
1913	461	238	699	81
1914	668	260	928	11
1915	891	76	967	0
1916	846	91	937	0
1917	978	100	1078	0
1918	690	180	870	19
1919	646	227	873	114
1920	647	314	961	0

There are two matters of some importance that the committee desires to bring to the attention of the Society:

The Regulations Governing Standing Committees provide that:

> "The annual reports of the standing committees shall be transmitted to the Secretary-Treasurer of the Society as early in the calendar year as possible and not less than eight weeks in advance of the date of the annual meeting. Preprints of these reports shall be mailed by the Secretary-Treasurer to every member of the Society at the earliest possible

subsequent date and not less than four weeks before the annual meeting, so that members may come to the meeting prepared to discuss such reports and that members not intending to be present at the meeting may contribute discussions by letter."

This year only one-third of all the committee reports had been received in complete form by the specified date. Another third of the reports had been received in incomplete form, while the remaining third had not been received at all. The committee fully appreciates that industrial conditions have undoubtedly made it difficult for a number of committees to get their reports in shape by the time required, and that in the case of at least one committee weather conditions affecting outdoor inspection is a controlling factor in the date of the preparation of the report. The committee nevertheless feels that many committees of the Society could readily meet the requirements of the Regulations by advancing the dates of their spring meetings one month. A number of committees now meet in April that could probably meet equally well in March and thus get their reports to the Secretary-Treasurer a full month earlier than they now do. This would materially relieve the congestion of editing and printing that now exists in the four to six weeks prior to the annual meeting, would give an opportunity for more careful editing and proof-reading than is now possible, and would result in a saving in the cost of printing by reducing the amount of overtime work required.

Committee E-6 believes that this matter merits careful consideration and recommends that the Executive Committee be requested to take it under advisement.

The other matter is a reorganization of the committee, as expressed in the following resolution adopted by the committee:

> "Voted unanimously that Committee E-6 on Papers and Publications recommends to the Executive Committee that its membership be reorganized after the annual meeting upon the following basis:
>
> "1. That the committee shall consist of nine members appointed by the Executive Committee, and *ex-officio* the Secretary-Treasurer of the Society, who shall be chairman of the committee.

"2. That the term of office of the members shall be three years, so arranged that the terms of office of three members shall expire each year. (Thus in first appointing the reorganized committee, three members would have a term of office of one year, three of two years, and three of three years. Reappointees would have terms of three years.")

As one of the administrative committees of the Society, the committee believes that opportunity should be afforded for a periodic revision of its personnel. The Executive Committee has approved the recommendations contained in this resolution, the provisions of which will be carried out after the annual meeting.

This report has been submitted to letter ballot of the committee, which consists of 9 members, of whom 8 have voted affirmatively, none negatively, and 1 has refrained from voting.

Respectfully submitted on behalf of the committee,

C. L. WARWICK,
Chairman.

A.S.T.M.
TENTATIVE STANDARDS

CONSISTING OF

SPECIFICATIONS, TESTS, METHODS AND DEFINITIONS.

The term Tentative Standards is applied to proposed Standards which are printed for one or more years with a view of eliciting criticism, of which the committee concerned will take due cognizance before recommending final action towards their adoption as standard.

Members of the Society and others are invited to direct written criticism of any of these Tentative Standards to the officer of the appropriate committee whose name and address appear in the footnote to the title of each Tentative Standard.

AMERICAN SOCIETY FOR TESTING MATERIALS
PHILADELPHIA, PA., U. S. A.
AFFILIATED WITH THE
INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE SPECIFICATIONS
FOR
WELDED STEEL PIPE.[1]

Serial Designation: A 53 - 20 T.

These specifications are issued under the fixed designation A 53; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1920.

Material Covered. 1. These specifications cover "standard" and "extra strong" welded steel pipe, but not "double extra strong" pipe. Pipe ordered under these specifications are intended for bending, flanging and other special purposes.

I. MANUFACTURE.

Process. 2. (*a*) The steel shall be of a soft weldable quality.

(*b*) All pipe 3 in. or under in nominal diameter may be butt-welded, unless otherwise specified. All pipe over 3 in. in nominal diameter shall be lap-welded.

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[1] Criticism of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1921, to Mr. F. M. Waring, Chairman of Committee A-1 on Steel, Pennsylvania System, Altoona, Pa.

These specifications, when adopted as standard, will supersede the present Standard Specifications for Welded Steel Pipe (Serial Designation: A 53-18), 1918 Book of A.S.T.M. Standards.

II. CHEMICAL PROPERTIES AND TESTS.

Chemical Composition. 3. Open-hearth steel shall conform to the following requirements as to chemical composition:

Phosphorus........................not over 0.05 per cent

III. PHYSICAL PROPERTIES AND TESTS.

Tension Tests. 4. (*a*) The material shall conform to the following minimum requirements as to tensile properties:

	BESSEMER.	OPEN-HEARTH.
Tensile strength, lb. per sq. in.	50 000	45 000
Yield point, " "	30 000	25 000
Elongation in 8 in., per cent	18	20

(*b*) The yield point shall be determined by the drop of the beam of the testing machine.

Hydrostatic Tests. 5. All pipe shall be tested at the mill to the hydrostatic pressures specified in Table I.

Flattening Tests. 6. (*a*) For lap-welded pipe over 2 in. in diameter, a section of pipe 6 in. long shall be flattened until the distance between the plates is one-third the outside diameter of the pipe with the weld located 45 deg. from the line of direction of the applied force, without developing cracks.

(*b*) For butt-welded pipe over 2 in. in diameter, a section of pipe 6 in. long shall be flattened until the distance between the plates is one-half the outside diameter of the pipe with the weld located 45 deg. from the line of direction of the applied force, without developing cracks.

Bend Tests. 7. For pipe 2 in. or under in diameter, a sufficient length of pipe shall bend cold through 90 deg. around a cylindrical mandrel the diameter of which is 15 times the nominal diameter of the pipe, without developing cracks at any portion and without opening the weld.

Test Specimens. 8. (*a*) Test specimens shall consist of sections cut from a pipe They shall be smooth on the ends and free from burrs.

(*b*) Tension test specimens shall be longitudinal.

(*c*) All specimens shall be tested cold.

Number of Tests. 9. One of each of the tests specified in Sections 4, 6, and 7, may be made on a length in each lot of 500 or less, of each size. Each length shall be subjected to the hydrostatic test.

Retests. 10. If the results of the physical tests of any lot do not conform to the requirements specified in Sections 4, 6 and 7, retests of two additional pipes shall be made, each of which shall conform to the requirements specified.

TABLE I.—HYDROSTATIC PRESSURES FOR WELDED PIPE.

(Pressures Expressed in Pounds per Square Inch)

(BLACK AND GALVANIZED)

Size, (Nominal Inside Diameter), in.	"Standard" Pipe.			"Extra Strong" Pipe.		
	Weight of Pipe per Linear Foot, Threaded and with Couplings, lb.	Butt-Weld.	Lap-Weld.	Weight of Pipe per Linear Foot, Plain Ends, lb.	Butt-Weld.	Lap-Weld.
$\frac{1}{8}$	.....	700	....	.....	700	....
$\frac{1}{4}$	.....	700	....	.....	700	....
$\frac{3}{8}$	.....	700	....	.....	700	....
$\frac{1}{2}$	.....	700	....	.....	700	....
$\frac{3}{4}$	.....	700	....	.....	700	....
1	.....	700	....	.....	700	....
$1\frac{1}{4}$	.....	700	1000	.....	1500	2500
$1\frac{1}{2}$	.....	700	1000	.....	1500	2500
2	.....	700	1000	.....	1500	2500
$2\frac{1}{2}$	.....	800	1000	.....	1500	2000
3	.....	800	1000	.....	1500	2000
$3\frac{1}{2}$	.....	...	1000	.....	....	2000
4	.....	...	1000	.....	....	2000
$4\frac{1}{2}$	.....	...	1000	.....	....	1800
5	.....	...	1000	.....	....	1800
6	.....	...	1000	.....	....	1800
7	.....	...	1000	.....	....	1500
8	25.00	...	800	.....	....	....
8	28.81	...	1000	43.39	....	1500
9	34.19	...	900	48.73	....	1200
10	32.00	...	600	.....	....	....
10	35.00	...	700	.....	....	....
10	41.13	...	900	54.74	....	1000
11	46.25	...	800	60.08	....	1000
12	45.00	...	600	.....	....	....
12	50.71	...	800	65.42	....	1000

For pipes over 12 in. in insidediameter, the test pressures should be calculated by the formula $P = \frac{2\,St}{D}$ in which P = pressure in pounds per square inch; S = fiber stress = 12,000 lb. per sq. in.; t = thickness of wall in inches; D = inside diameter in inches.

TABLE II.—STANDARD WEIGHTS OF WELDED PIPE.

(BLACK AND GALVANIZED)

Size (Nominal Inside Diameter), in.	"Standard" Pipe.				"Extra Strong" Pipe.	
	Outside Diameter, in.	Number of Threads per Inch.	Thickness, in.	Weight of Pipe per Linear Foot, Threaded and with Couplings, lb.	Thickness, in.	Weight of Pipe per Linear Foot, Plain Ends, lb.
1/8	0.405	27	0.068	0.25	0.095	0.31
1/4	0.540	18	0.088	0.43	0.119	0.54
3/8	0.675	18	0.091	0.57	0.126	0.74
1/2	0.840	14	0.109	0.85	0.147	1.09
3/4	1.050	14	0.113	1.13	0.154	1.47
1	1.315	11 1/2	0.133	1.68	0.179	2.17
1 1/4	1.660	11 1/2	0.140	2.28	0.191	3.00
1 1/2	1.900	11 1/2	0.145	2.73	0.200	3.63
2	2.375	11 1/2	0.154	3.68	0.218	5.02
2 1/2	2.875	8	0.203	5.82	0.276	7.66
3	3.500	8	0.216	7.62	0.300	10.25
3 1/2	4.000	8	0.226	9.20	0.318	12.51
4	4.500	8	0.237	10.89	0.337	14.98
4 1/2	5.000	8	0.247	12.64	0.355	17.61
5	5.563	8	0.258	14.81	0.375	20.78
6	6.625	8	0.280	19.19	0.432	28.57
7	7.625	8	0.301	23.77	0.500	38.05
*8	8.625	8	0.277	25.00	.....	.....
8	8.625	8	0.322	28.81	0.500	43.39
9	9.625	8	0.342	34.19	0.500	48.73
*10	10.750	8	0.279	32.00	.....	.....
*10	10.750	8	0.307	35.00	.....	.....
10	10.750	8	0.365	41.13	0.500	54.74
11	11.750	8	0.375	46.25	0.500	60.08
*12	12.750	8	0.330	45.00	.....	.....
12	12.750	8	0.375	50.71	0.500	65.42

* Unless specifically stated on the order the lighter weights will not be furnished. Weights given in the table are for pipes up to and including 12 in. in nominal inside diameter, with threaded ends and couplings; sizes larger than shown in the table are measured by the outside diameter and usually have plain ends; for such sizes it will be necessary to accept Manufacturers' weights or calculate the weights on the basis of one cubic inch of iron or steel weighing 0.2833 lb.

IV. STANDARD WEIGHTS.

Standard Weights.

11. (*a*) The standard weights for pipe of various inside diameters are given in Table II.

(*b*) Nipples shall be cut from pipe of the same weight and quality as described in these specifications.

Permissible Variations.

12. The weight of the pipe shall not vary more than 5 per cent from that specified in Table II.

V. WORKMANSHIP AND FINISH.

Workmanship.

13. (*a*) For pipe 1½ in. or under in inside diameter, the outside diameter at any point shall not vary more than $\frac{1}{64}$ in. over nor more than $\frac{1}{32}$ in. under the standard size. For pipe 2 in. or over in inside diameter, the outside diameter shall not vary more than 1 per cent over or under the standard size.

(*b*) Each length of "standard" pipe shall be provided with the prevailing standard thread, which will make a tight joint when tested to the specified internal hydrostatic pressure at the mill. The threads shall not vary more than one and one-half turns either way, when tested with a Pratt & Whitney standard gage. All burrs at the ends of the pipe shall be removed.

(*c*) Unless otherwise ordered, pipe shall be furnished in random lengths of 16 to 22 ft., but not more than 5 per cent of the total number of lengths furnished may be "jointers," which are two pieces coupled together. When ordered with plain ends, 5 per cent may be furnished in lengths of 12 ft. or over.

(*d*) Each "standard" pipe shall be provided with a coupling, having clean-cut threads of such a pitch diameter as to make a tight joint. Couplings may be of wrought iron or steel.

(*e*) Unless otherwise specified, "extra strong" pipe shall be furnished in random lengths, with plain ends.

Finish.

14. The finished pipe shall be reasonably straight and free from injurious defects.

VI. INSPECTION AND REJECTION.

Inspection.

15. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the pur-

chaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the pipe ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the pipe are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 16. Each length of pipe which develops injurious defects in shop working or application will be rejected, and the manufacturer shall be notified.

AMERICAN SOCIETY FOR TESTING MATERIALS

PHILADELPHIA, PA., U. S. A.

AFFILIATED WITH THE

INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE SPECIFICATIONS
FOR
STEEL TIE PLATES.[1]

Serial Designation: A 67 – 20 T.

These specifications are issued under the fixed designation A 67; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1916; REVISED, 1917, 1918, 1920.

In view of the abnormal difficulty in obtaining materials in time of war, the rejection limits for phosphorus in acid steels shall be raised 0.01 per cent above the values given in these specifications. This shall be effective during the period of the war and until otherwise ordered by the Society.

Material Covered.

1. These specifications cover two grades of steel tie plates, namely: soft and medium. The soft grade will be used unless otherwise specified.

I. MANUFACTURE.

Process.

2. The steel may be made by the Bessemer or open-hearth process.

II. CHEMICAL PROPERTIES AND TESTS.

Chemical Composition.

3. The steel shall conform to the following requirements as to chemical composition:

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1921, to Mr. F. M. Waring, Chairman of Committee A-1 on Steel, Pennsylvania System, Altoona, Pa.

BESSEMER.	SOFT GRADE.	MEDIUM GRADE.
Carbon, per cent	not under 0.06	not under 0.12
Phosphorus, per cent	not over 0.10	not over 0.10
OPEN-HEARTH.		
Carbon, per cent	not under 0.12	not under 0.20
Phosphorus, per cent	not over 0.06	not over 0.06

Ladle Analyses. 4. (*a*) A carbon determination shall be made of each melt of Bessemer steel, and two analyses every 24 hours representing the average of the elements carbon, manganese, phosphorus and sulfur, contained in the steel, one for each day and night turn respectively. These analyses shall be made from drillings taken at least $\frac{1}{8}$ in. beneath the surface of a test ingot obtained during the pouring of the melts. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 3.

(*b*) An analysis of each melt of open-hearth steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus and sulfur. This analysis shall be made from drillings taken at least $\frac{1}{8}$ in. beneath the surface of a test ingot obtained during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 3.

Check Analyses. 5. An analysis may be made by the purchaser from a finished tie plate representing each melt of open-hearth steel, and each melt or lot of 10 tons of Bessemer steel. The carbon content thus determined shall not be less than that specified in Section 3, and the phosphorus content shall not exceed that specified in Section 3 by more than 25 per cent.

III. PHYSICAL PROPERTIES AND TESTS.

Bend Tests. 6. The bend test specimens specified in Section 7 shall bend cold through 180 deg. around a pin the diameter of which is equal to the thickness of the specimen for the soft grade, and to twice the thickness of the specimen for the medium grade, without cracking on the outside of the bent portion.

Test Specimens. 7. Bend test specimens shall be taken from the finished tie plates, or from the rolled bars; and longitudinally with the rolling. They shall be rectangular in section, not less than $\frac{1}{2}$ in. in width between the planed sides, and shall have two parallel faces as rolled. They shall be free from ribs or projections. Where the design of the tie plates is such that the specimen cannot be taken between the ribs or projections, these ribs or projections shall, in preparing the specimen, be planed off even with the main surface of the tie plate.

Optional Bend Tests.

8. If preferred by the manufacturer and approved by the purchaser, the following bend test may be substituted for that described in Section 6:

A piece of the rolled bar shall bend cold through 90 deg. around a pin the diameter of which is equal to the thickness of the section where bent for the soft grade, and to twice the thickness of the section where bent for the medium grade, without cracking on the outside of the bent portion.

Number of Tests.

9. (*a*) One bend test shall be made from each melt of open-hearth steel, or from each melt or lot of 10 tons of Bessemer steel.

(*b*) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

IV. WORKMANSHIP AND FINISH.

Workmanship.

10. The tie plates shall be smoothly rolled, true to templet, and shall be straight and out of wind on the surface which will form the bearing for the rail. They shall conform to the dimensions specified by the purchaser, with the following permissible variations:

(*a*) For plates with shoulders parallel to the direction of rolling, a variation of $\frac{1}{32}$ in. in thickness, $\frac{1}{8}$ in. in rolled width, and $\frac{3}{16}$ in. in sheared length will be permitted.

(*b*) For plates with shoulders perpendicular to the direction of rolling, a variation of $\frac{1}{32}$ in. in thickness, $\frac{3}{16}$ in. in rolled width, and $\frac{1}{4}$ in. in sheared length will be permitted. The distance from the face of shoulder to the outside end of plate shall not vary more than $\frac{1}{4}$ in., and from the face of shoulder to the inside end not more than $\frac{1}{2}$ in.

Finish.

11. The finished tie plates shall be free from burrs and other surface deformations caused by the shearing and punching;

they shall also be free from other injurious defects and shall have a workmanlike finish.

V. MARKING.

Marking. 12. The name or brand of the manufacturer, the section and the year of manufacture shall be rolled in raised letters and figures on the outside of the shoulder of the plates, and a portion of this marking shall appear on each finished tie plate.

VI. INSPECTION AND REJECTION.

Inspection. 13. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the tie plates ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the tie plates are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 14. (*a*) Unless otherwise specified, any rejection based on tests made in accordance with Section 5 shall be reported within five working days from the receipt of samples.

(*b*) Tie plates which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

Rehearing. 15. Samples tested in accordance with Section 5, which represent rejected tie plates, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

AMERICAN SOCIETY FOR TESTING MATERIALS

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TENTATIVE SPECIFICATIONS
FOR
BOILER AND FIREBOX STEEL FOR STATIONARY SERVICE.[1]

Serial Designation: A 70 - 18 T.

These specifications are issued under the fixed designation A 70; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1916; REVISED, 1917, 1918.

Material Covered.

1. These specifications cover two classes of steel for boilers for stationary service, namely: flange and firebox.

I. MANUFACTURE.

Process.

2. The steel shall be made by the open-hearth process.

II. CHEMICAL PROPERTIES AND TESTS.

Chemical Composition.

3. The steel shall conform to the following requirements as to chemical composition:

		FLANGE.	FIREBOX.	
Carbon	For plates ¾ in. or under in thickness	.....	0.12 - 0.25	per cent
	For plates over ¾ in. in thickness	.....	0.12 - 0.30	"
Manganese		0.30 - 0.60	0.30 - 0.60	"
Phosphorus	Acid	not over 0.05	not over 0.04	"
	Basic	" " 0.04	" " 0.035	"
Sulfur		" " 0.05	" " 0.04	"

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1921, to Mr. F. M. Waring, Chairman of Committee A-1 on Steel, Pennsylvania System, Altoona, Pa.

Ladle Analyses.

4. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of the elements specified in Section 3. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 3.

Check Analyses.

5. An analysis may be made by the purchaser from a broken tension test specimen representing each plate as rolled. The chemical composition thus determined shall conform to the requirements specified in Section 3.

III. PHYSICAL PROPERTIES AND TESTS.

Tension Tests.

6. (*a*) The material shall conform to the following requirements as to tensile properties:

	FLANGE AND FIREBOX.
Tensile strength, lb. per sq. in.	55 000 – 65 000
Yield point, min., " "	0.5 tens. str.
Elongation in 8 in., min., per cent	$\frac{1\,500\,000}{\text{Tens. str.}}$;

but for firebox steel not less than 24 per cent, subject to the modifications of Section 7.

(*b*) The yield point shall be determined by the drop of the beam of the testing-machine.

Modifications in Elongation.

7. (*a*) For material over $\frac{3}{4}$ in. in thickness, a deduction of 0.5 from the percentages of elongation specified in Section 6 (*a*) shall be made for each increase of $\frac{1}{8}$ in. in thickness above $\frac{3}{4}$ in., to a minimum of 20 per cent.

(*b*) For material $\frac{1}{4}$ in. or under in thickness, the elongation shall be measured on a gage length of 24 times the thickness of the specimen.

Bend Tests.

8. The test specimen shall bend cold through 180 deg. without cracking on the outside of the bent portion, as follows: For material 1 in. or under in thickness, around a pin the diameter of which is equal to the thickness of the specimen; and for material over 1 in. in thickness, around a pin the diameter of which is equal to twice the thickness of the specimen.

Homogeneity Tests.

9. For firebox steel, a sample taken from a broken tension test specimen shall not show any single seam or cavity more than $\frac{1}{4}$ in. long, in either of the three fractures obtained in the test for homogeneity, which shall be made as follows:

The specimen shall be either nicked with a chisel or grooved on a machine, transversely, about $\frac{1}{16}$ in. deep, in three places about 2 in. apart. The first groove shall be made 2 in. from the square end; each succeeding groove shall be made on the opposite side from the preceding one. The specimen shall then be firmly held in a vise, with the first groove about $\frac{1}{4}$ in. above the jaws, and the projecting end broken off by light blows of a hammer, the bending being away from the groove. The specimen shall be broken at the other two grooves in the same manner. The object of this test is to open and render visible to the eye any seams due to failure to weld up or to interposed foreign matter, or any cavities due to gas bubbles in the ingot. One side of each fracture shall be examined and the lengths of the seams and cavities determined, a pocket lens being used if necessary.

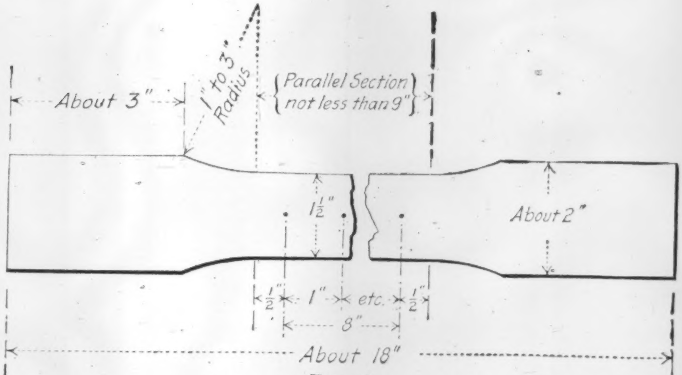

FIG. 1.

Test Specimens.

10. (*a*) Tension test specimens shall be taken longitudinally from the bottom of the finished rolled material, and bend test specimens shall be taken transversely from the middle of the top of the finished rolled material. The longitudinal test specimen shall be taken in the direction of the longitudinal axis of the ingot, and the transverse test specimen at right angles to that axis.

(*b*) Tension and bend test specimens shall be of the full thickness of material as rolled, and shall be machined to the form and dimensions shown in Fig. 1; except that bend test specimens may be machined with both edges parallel.

Number of Tests.

11. (*a*) One tension and one bend test shall be made from each plate as rolled.

(*b*) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(*c*) If the percentage of elongation of any tension test specimen is less than that specified in Section 6 (*a*) and any part of the fracture is outside the middle third of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

IV. PERMISSIBLE VARIATIONS IN WEIGHT AND THICKNESS.

Permissible Variations.

12. The thickness of each plate shall not vary more than 0.01 in. under that ordered.

TABLE I.—PERMISSIBLE OVERWEIGHTS OF PLATES ORDERED TO THICKNESS.

Ordered Thickness, in.	Permissible Excess in Average Weights per Square Foot of Plates for Widths Given, Expressed in Percentages of Nominal Weights.									Ordered Thickness, in.
	Under 48 in.	48 to 60 in., excl.	60 to 72 in., excl.	72 to 84 in., excl.	84 to 96 in., excl.	96 to 108 in., excl.	108 to 120 in., excl.	120 to 132 in., excl.	132 in. or over.	
Under 1/8	9	10	12	14	..	..	..	..	..	Under 1/8
1/8 to 3/16 excl.	8	9	10	12	..	..	..	..	..	1/8 to 3/16 excl.
3/16 " 1/4 "	7	8	9	10	12	..	..	..	..	3/16 " 1/4 "
1/4 " 5/16 "	6	7	8	9	10	12	14	16	19	1/4 " 5/16 "
5/16 " 3/8 "	5	6	7	8	9	10	12	14	17	5/16 " 3/8 "
3/8 " 7/16 "	4.5	5	6	7	8	9	10	12	15	3/8 " 7/16 "
7/16 " 1/2 "	4	4.5	5	6	7	8	9	10	13	7/16 " 1/2 "
1/2 " 5/8 "	3.5	4	4.5	5	6	7	8	9	11	1/2 " 5/8 "
5/8 " 3/4 "	3	3.5	4	4.5	5	6	7	8	9	5/8 " 3/4 "
3/4 " 1 "	2.5	3	3.5	4	4.5	5	6	7	8	3/4 " 1 "
1 or over	2.5	2.5	3	3.5	4	4.5	5	6	7	1 or over

The overweight of each lot[1] in each shipment shall not exceed the amount given in Table I. One cubic inch of rolled steel is assumed to weigh 0.2833 lb.

V. FINISH.

Finish.

13. The finished material shall be free from injurious defects and shall have a workmanlike finish.

VI. MARKING.

Marking.

14. (*a*) The name or brand of the manufacturer, melt or slab number, class, and lowest tensile strength for its grade

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[1] The term "lot" applied to Table I means all of the plates of each group width and group thickness.

specified in Section 6 (*a*), shall be legibly stamped on each plate. The melt or slab number shall be legibly stamped on each test specimen.

(*b*) When specified on the order, plates shall be match-marked as defined in Paragraph (*c*) so that the test specimens representing them may be identified. When more than one plate is sheared from a single slab or ingot, each shall be match-marked so that they may all be identified with the test specimens representing them.

(*c*) Each match mark shall consist of two over-lapping circles each not less than 1½ in. in diameter, placed upon the shear lines, and made by separate impressions of a single-circle steel die.

(*d*) Match-marked coupons shall match with the sheets represented and only those which match properly shall be accepted.

VII. INSPECTION AND REJECTION.

Inspection.

15. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection.

16. (*a*) Unless otherwise specified, any rejection based on tests made in accordance with Section 5, shall be reported within five working days from the receipt of samples.

(*b*) Material which shows injurious defects subsequent to its acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

Rehearing.

17. Samples tested in accordance with Section 5, which represent rejected material, shall be preserved for two weeks from date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

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TENTATIVE SPECIFICATIONS
FOR
CARBON TOOL STEEL.[1]

Serial Designation: A 71 – 20 T.

These specifications are issued under the fixed designation A 71; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917; REVISED, 1920.

Material Covered. 1. These specifications cover three classes of carbon tool steel determined by the chemical composition specified in Section 3.

I. MANUFACTURE.

Process. 2. The steel shall be made by the crucible or electric process, with the exception of Grade C, which may be made by the open-hearth process.

II. CHEMICAL PROPERTIES AND TESTS.

Chemical Composition. 3. The steel shall conform to the following requirements as to chemical composition:

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1921, to Mr. F. M. Waring, Chairman of Committee A-1 on Steel, Pennsylvania System, Altoona, Pa.

ELEMENTS CONSIDERED.	CLASS A.	CLASS B.	CLASS C.
Carbon, per cent	The percentage of carbon may vary by ranges of 0.10 per cent with rejection limits plus or minus 0.025 per cent.[1]	(Same as Class A)	(Same as Class A)
Manganese, max., per cent	0.40	0.45	0.60
Phosphorus, max., per cent	0.02	0.025	0.035
Sulfur, max., per cent	0.025	0.035	0.04
Silicon, max., per cent	0.35	0.35	0.25

Chemical Analyses.

4. In case of dispute, the chemical analyses shall be made in accordance with the Standard Methods for Chemical Analysis of Plain Carbon Steel (Serial Designation: A 33) of the American Society for Testing Materials.[2]

III. PERMISSIBLE VARIATIONS IN DIMENSIONS.

Permissible Variations.

5. The permissible variations in the size of the material ordered shall be agreed upon by the contractor and the purchaser.

IV. FINISH.

Finish.

6. The material shall be free from injurious defects, and shall have a workmanlike finish.

V. MARKING.

Marking.

7. The identification marks to be placed on the material shall be agreed upon by the contractor and the purchaser.

VI. INSPECTION AND REJECTION.

Inspection.

8. The contractor shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications.

Rejection.

9. Material which does not conform to the chemical composition and agreed variations, or which at any time shows injurious defects inherent in the steel, will be rejected, and the contractor shall be notified.

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[1] As an illustration, tool steel may be ordered with a carbon range from 0.60 to 0.70 per cent, with rejection limits of 0.575 and 0.725 per cent, or from 0.75 to 0.85 per cent, with rejection of 0.725 and 0.875 per cent.

[2] 1918 Book of A.S.T.M. Standards.

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TENTATIVE SPECIFICATIONS
FOR
LOW-CARBON-STEEL TRACK BOLTS.[1]

Serial Designation: A 76 – 20 T.

These specifications are issued under the fixed designation A 76; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1918; REVISED, 1920.

In view of the abnormal difficulty in obtaining materials in time of war, the rejection limits for phosphorus in acid steels shall be raised 0.01 per cent above the values given in these specifications. This shall be effective during the period of the war and until otherwise ordered by the Society.

I. MANUFACTURE.

Process.

1. (*a*) The steel may be made by the Bessemer or open-hearth process.

(*b*) The threads may be cut or rolled.

II. CHEMICAL PROPERTIES AND TESTS.

Chemical Composition.

2. (*a*) The steel for the bolts shall conform to the following requirements as to chemical composition:

Phosphorus	Bessemer	not over 0.10 per cent.
	Open-hearth	" " 0.05 " .

(*b*) The steel for the nuts shall be "soft steel."

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1921, to Mr. F. M. Waring, Chairman of Committee A-1 on Steel, Pennsylvania System, Altoona, Pa.

Ladle Analyses.

3. (*a*) A carbon determination shall be made of each melt of Bessemer steel, and two analyses every 24 hours representing the average of the elements carbon, manganese, phosphorus and sulfur, contained in the steel, one for each day and night turn respectively. These analyses shall be made from drillings taken at least $\frac{1}{8}$ in. beneath the surface of a test ingot obtained during the pouring of the melts. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 2.

(*b*) An analysis of each melt of open-hearth steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus and sulfur. This analysis shall be made from drillings taken at least $\frac{1}{8}$ in. beneath the surface of a test ingot obtained during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 2.

Check Analyses.

4. An analysis may be made by the purchaser from a finished bolt representing each melt. The phosphorus content thus determined shall not exceed that specified in Section 2 by more than 25 per cent.

III. PHYSICAL PROPERTIES AND TESTS.

Tension Tests.

5. The stock from which the bolts are made shall conform to the following requirements as to tensile properties:

Tensile strength, lb. per sq. in	55 000 – 70 000
Elongation in 8 in., min., per cent...........	$\frac{1\,500\,000}{\text{Tens. str.}}$

Bend Tests.

6. The test specimen shall bend cold through 180 deg. flat on itself without cracking on the outside of the bent portion.

Test Specimens.

7. Tension and bend test specimens shall be taken from the full-size rolled bars. Tension test specimens shall be of 8-in. gage length.

Number of Tests.

8. (*a*) One tension and one bend test shall be made from each melt of steel. When the melts can not be identified, one tension and one bend test shall be made from each lot of 10 tons or fraction thereof.

(*b*) If any test specimen develops flaws, it may be discarded and another specimen substituted.

(*c*) If the percentage of elongation of any tension test specimen is less than that specified in Section 5 and any part of the fracture is outside the middle third of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

Retests. 9. If the results of the physical tests of any test lot do not conform to the requirements specified, two additional tension and two additional bend tests shall be made from such lot, all of which shall conform to the requirements specified.

IV. WORKMANSHIP AND FINISH.

Workmanship. 10. The bolts and nuts shall conform to the dimensions specified by the purchaser. They shall be neatly formed and free from fins or nicking. The head of the bolt shall be concentric with and firmly joined to the shank, with the underside at right angles to the axis of the bolt. The threads shall be sharp and true to gage and of the design specified by the purchaser. The nuts shall have a hand free fit on the bolt from two to six turns, and wrench tight the balance of the screw length without distorting the threads or twisting the shank. They shall be screwed on the bolts before packing, a sufficient number of turns to hold them in place until used. A variation of $\frac{1}{32}$ in. under and $\frac{1}{64}$ in. over the specified diameter of the shank of the bolt will be permitted. The diameter of rolled thread shall not exceed the diameter of the shank more than $\frac{1}{16}$ in. for bolts $\frac{7}{8}$ in. in diameter and under, nor more than $\frac{3}{32}$ in. for bolts 1 in. in diameter and over. The outside diameter of the finished rolled thread shall not exceed the diameter of the shank of a cut thread bolt of corresponding size. The length of the bolt under the head shall not vary more than $\frac{1}{8}$ in. from that specified. A variation in the dimensions of the elliptical shoulders under the head of $\frac{1}{32}$ in. and a taper of the shoulder of $\frac{1}{32}$ in. will be permitted.

Finish. 11. The finished bolts and nuts shall be free from injurious defects and shall have a workmanlike finish.

V. MARKING.

Marking. 12. (*a*) A letter or brand indicating the manufacturer shall be pressed on the head of the bolt when it is formed.

(*b*) Bolts shall be packed in serviceable packages. All packages shall be plainly marked as to material, size of bolts and name of manufacturer.

VI. INSPECTION AND REJECTION.

Inspection. 13. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the bolts and nuts ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the bolts and nuts are being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 14. Bolts and nuts which show injurious defects subsequent to their acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

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TENTATIVE SPECIFICATIONS
FOR
ELECTRIC CAST STEEL ANCHOR CHAIN.[1]

Serial Designation: A 77 – 20 T.

These specifications are issued under the fixed designation A 77; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1918; REVISED, 1920.

Material Covered. 1. These specifications cover the cast steel to be used in all parts of the complete chain, including stud links, enlarged links, end links, shackles and shackle pins for anchor chain $1\frac{3}{8}$ in. and over.

I. MANUFACTURE.

Process. 2. (*a*) The steel shall be made by the electric furnace process, and all castings shall be produced in dry sand molds or cores.

(*b*) Each complete shot of chain shall be heat-treated in such manner that the treatment will be complete and uniform throughout its entire length.

Weight. 3. The weight of each shot of chain shall not be less than the minimum weight specified in Table I.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1921, to Mr. F. M. Waring, Chairman of Committee A-1 on Steel, Pennsylvania System, Altoona, Pa.

II. PHYSICAL TESTS.

Test Chains.

4. (*a*) Three links shall be selected by the inspector representing the purchaser from any part of each 15 fathoms of chain or portion thereof, and cut out for testing purposes. Such links shall be marked for identification and heat-treated with the length they represent.

(*b*) Such test chains shall become the basis, as provided in Section 5, for the acceptance or rejection of the material entering into the shot of chain they represent.

Breaking Tests.

5. (*a*) One of the test chains shall be pulled in an approved static testing machine to a breaking load in accordance with the loads specified in Table II. If this first test chain withstands the required tensile breaking load, the shot of chain which it represents shall be accepted so far as this test is concerned.

TABLE I.—MINIMUM WEIGHT PER SHOT OF 15 FATHOMS.

Size of Chain, in.	Weight, lb.	Size of Chain, in.	Weight, lb.	Size of Chain, in.	Weight, lb.
$1\frac{3}{8}$	1 625	$2\frac{1}{8}$	3 785	$2\frac{7}{8}$	7 015
$1\frac{7}{16}$	1 775	$2\frac{3}{16}$	4 015	$2\frac{15}{16}$	7 330
$1\frac{1}{2}$	1 935	$2\frac{1}{4}$	4 245	3	7 650
$1\frac{9}{16}$	2 090	$2\frac{5}{16}$	4 485	$3\frac{1}{16}$	7 980
$1\frac{5}{8}$	2 235	$2\frac{3}{8}$	4 725	$3\frac{1}{8}$	8 320
$1\frac{11}{16}$	2 410	$2\frac{7}{16}$	4 960	$3\frac{3}{16}$	8 660
$1\frac{3}{4}$	2 590	$2\frac{1}{2}$	5 265	$3\frac{1}{4}$	9 010
$1\frac{13}{16}$	2 785	$2\frac{9}{16}$	5 535	$3\frac{5}{16}$	9 360
$1\frac{7}{8}$	2 975	$2\frac{5}{8}$	5 815	$3\frac{3}{8}$	9 725
$1\frac{15}{16}$	3 175	$2\frac{11}{16}$	6 105	$3\frac{7}{16}$	10 095
2	3 355	$2\frac{3}{4}$	6 405	$3\frac{1}{2}$	10 475
$2\frac{1}{16}$	3 570	$2\frac{13}{16}$	6 705	$3\frac{3}{4}$	12 025

(*b*) If any link in the first test chain fails to withstand the required tensile breaking load, the second test chain shall be subjected to the same test. Prior to this retest the shot of chain and the second test chain may be subjected to a re-heat treatment at the option of the manufacturer. If the second test chain passes the required test the shot of chain which it represents shall be accepted so far as this test is concerned. If the second test chain fails to pass the required test the shot of chain shall be rejected.

Proof Tests.

6. (*a*) The complete shot of chain shall then be subjected to a proof test, which shall consist of anchoring each end thereof in an approved static testing machine and subjecting it to the proof load shown in Table II, according to its respective size. If the shot of chain passes this test it shall be accepted.

(*b*) If any link or links, in any one shot of 15 fathoms, fail during the proof test a new link or links may be cast in and the shot re-treated and again subjected to the proof tests. If any link fails on this retest the shot shall be rejected.

TABLE II.—PROOF AND BREAKING LOADS.

Size of Chain, in.	Proof Test, lb.	Breaking Test lb.	Size of Chain, in.	Proof Test, lb.	Breaking Test, lb.	Size of Chain, in.	Proof Test, lb.	Breaking Test, lb.
$1\frac{3}{8}$	114 000	160 000	$2\frac{1}{8}$	255 000	357 000	$2\frac{7}{8}$	431 500	604 000
$1\frac{7}{16}$ ...	124 500	175 000	$2\frac{3}{16}$	270 000	378 000	$2\frac{15}{16}$	444 500	622 000
$1\frac{1}{2}$	131 500	184 000	$2\frac{1}{4}$	285 000	400 000	3........	457 000	640 000
$1\frac{9}{16}$ ...	137 500	193 000	$2\frac{5}{16}$	302 000	423 000	$3\frac{1}{16}$	469 500	658 000
$1\frac{5}{8}$ ...	149 000	208 000	$2\frac{3}{8}$	318 500	446 000	$3\frac{1}{8}$	482 000	676 000
$1\frac{11}{16}$ ...	160 500	225 000	$2\frac{7}{16}$	335 000	470 000	$3\frac{3}{16}$	494 500	693 000
$1\frac{3}{4}$	173 000	242 000	$2\frac{1}{2}$	353 000	494 000	$3\frac{1}{4}$	506 500	710 000
$1\frac{13}{16}$ ...	185 500	260 000	$2\frac{9}{16}$	366 000	512 000	$3\frac{5}{16}$	518 500	726 000
$1\frac{7}{8}$	198 000	278 000	$2\frac{5}{8}$	379 000	531 000	$3\frac{3}{8}$	530 500	742 000
$1\frac{15}{16}$ ...	211 500	296 000	$2\frac{11}{16}$	392 500	550 000	$3\frac{7}{16}$	541 500	758 000
2.......	226 000	316 000	$2\frac{3}{4}$	405 500	568 000	$3\frac{1}{2}$	553 000	775 000
$2\frac{1}{16}$ ...	240 000	336 000	$2\frac{13}{16}$	418 500	586 000	$3\frac{3}{4}$	588 500	824 000

Shock Tests.

7. In addition to the breaking and proof tests specified in Sections 5 and 6, the material entering into the manufacture of the chain shall be subjected to such shock or bend tests as shall be agreed upon between the manufacturer and the purchaser, in order to determine its shock-resisting qualities.

Use of Second Test Chain.

8. In the event that only one test chain is subjected to test, the remaining test chain may be united with and become a part of another complete shot of chain.

III. DIMENSIONS AND PERMISSIBLE VARIATIONS.

Dimensions.

9. All castings shall conform to the dimensions and permissible variations agreed upon between the manufacturer and the purchaser.

IV. FINISH.

Finish.

10. All castings shall be free from shrinkage, porosity or other injurious defects which would affect the strength of the chain, and shall have a workmanlike finish.

V. MARKING.

Marking.

11. Each link shall be legibly stenciled with its heat number. Each shot of chain accepted shall be legibly stenciled in accordance with the requirements of the purchaser.

VI. INSPECTION.

Inspection.

12. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the chain ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the chain is being furnished in accordance with these specifications. Tests and inspection at the place of manufacture shall be made prior to shipment, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

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TENTATIVE SPECIFICATIONS
FOR
STEEL PLATES FOR FORGE WELDING.[1]

Serial Designation: A 78 - 20 T.

These specifications are issued under the fixed designation A 78; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1919; REVISED, 1920.

Material Covered. 1. These specifications apply to steel plates for forge welding for tank cars and for similar construction.

I. MANUFACTURE.

Process. 2. The steel shall be made by the open-hearth or any other process approved by the purchaser.

II. CHEMICAL PROPERTIES AND TESTS.

Chemical Composition. 3. (*a*) The steel shall conform to the following requirements as to chemical composition:

Carbon	for plates ¾ in. or under in thickness	not over 0.18 per cent
	for plates over ¾ in. in thickness	" " 0.20 "
Manganese		0.40-0.60 "
Phosphorus		not over 0.04 "
Sulfur		" " 0.05 "

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1921, to Mr. F. M. Waring, Chairman of Committee A-1 on Steel, Pennsylvania System, Altoona, Pa.

(*b*) The composition of steel for forge-welding plates should preferably be free from silicon, nickel or chromium. Where these elements are present the maximum quantity of any one shall not exceed 0.05 per cent.

Ladle Analyses. 4. An analysis of each melt of steel shall be made by the manufacturer to determine the percentages of carbon, manganese, phosphorus and sulfur. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 3.

Check Analyses. 5. An analysis may be made by the purchaser from a broken tension test specimen representing each melt. The chemical composition thus determined shall conform to the requirements specified in Section 3.

III. PHYSICAL PROPERTIES AND TESTS.

Tension Tests. 6. (*a*) The material shall conform to the following minimum requirements as to tensile properties:

Tensile strength, lb. per sq. in.	50 000
Yield point, lb. per sq. in.	0.5 tens. str.
Elongation in 8 in., per cent	$\frac{1\ 500\ 000}{\text{Tens. str.}}$

(*b*) The yield point shall be determined by the drop of the beam of the testing machine.

Modifications in Elongation. 7. (*a*) For material over $\frac{3}{4}$ in. in thickness, a deduction of 1 from the percentage of elongation specified in Section 6 (*a*) shall be made for each increase of $\frac{1}{8}$ in. in thickness above $\frac{3}{4}$ in., to a minimum of 20 per cent.

(*b*) For material under $\frac{5}{16}$ in. in thickness, a deduction of 2.5 from the percentage of elongation in 8 in. specified in Section 6 (*a*) shall be made for each decrease of $\frac{1}{16}$ in. in thickness below $\frac{5}{16}$ in.

Bend Tests. 8. The test specimen shall bend cold through 180 deg. flat on itself without cracking on the outside of the bent portion.

Test Specimens.

9. (*a*) Tension and bend test specimens shall be taken from the finished rolled material.

(*b*) Tension and bend test specimens, except as specified in Paragraph (*c*), shall be of the full thickness of material as rolled; and may be machined to the form and dimensions shown in Fig. 1, or with both edges parallel.

(*c*) Tension and bend test specimens for plates over $1\frac{1}{2}$ in. in thickness may be machined to a thickness of at least $\frac{3}{4}$ in. for a length of at least 9 in.

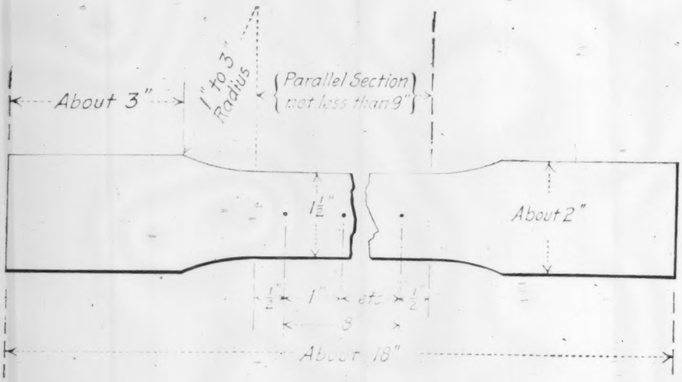

FIG. 1.

Number of Tests.

10. (*a*) One tension and one bend test shall be made from each melt; except that if material from one melt differs $\frac{3}{8}$ in. or more in thickness, one tension and one bend test shall be made from both the thickest and the thinnest material rolled.

(*b*) If any test specimen shows defective machining or develops flaws, it may be discarded and another specimen substituted.

(*c*) If the percentage of elongation of any tension test specimen is less than that specified in Section 6 (*a*) and any part of the fracture is outside the middle third of the gage length, as indicated by scribe scratches marked on the specimen before testing, a retest shall be allowed.

IV. PERMISSIBLE VARIATIONS IN WEIGHT AND THICKNESS.

Permissible Variation.

11. The cross-section or weight of plates shall be covered by the following permissible variations. One cubic inch of rolled steel is assumed to weigh 0.2833 lb.

(*a*) *When Ordered to Weight per Square Foot:* The weight of each lot[1] in each shipment shall not vary from the weight ordered more than the amount given in Table I.

(*b*) *When Ordered to Thickness:* The thickness of each plate shall not vary more than 0.01 in. under that ordered.

The overweight of each lot[2] in each shipment shall not exceed the amount given in Table II.

V. FINISH.

Finish.

12. The finished material shall be free from injurious defects and shall have a workmanlike finish.

VI. MARKING.

Marking.

13. The name or brand of the manufacturer and the melt number shall be legibly rolled or stamped on all finished material. The melt number shall be legibly marked, by stamping if practicable, on each test specimen.

VII. INSPECTION AND REJECTION.

Inspection.

14. The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests (except check analyses) and inspection shall be made at the place of manufacture prior to shipment, unless otherwise specified, and shall be so conducted as not to interfere unnecessarily with the operation of the works.

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[1] The term "lot" applied to Table I means all of the plates of each group width and group weight.

[2] The term "lot" applied to Table II means all of the plates of each group width and group thickness.

TABLE I.—PERMISSIBLE VARIATIONS OF PLATES ORDERED TO WEIGHT.

ORDERED WEIGHT, LB. PER SQ. FT.	PERMISSIBLE VARIATIONS IN AVERAGE WEIGHTS PER SQUARE FOOT OF PLATES FOR WIDTHS GIVEN, EXPRESSED IN PERCENTAGES OF ORDERED WEIGHTS.																		ORDERED WEIGHT, LB. PER SQ. FT.
	Under 48 in.		48 to 60 in., excl.		60 to 72 in., excl.		72 to 84 in., excl.		84 to 96 in., excl.		96 to 108 in., excl.		108 to 120 in., excl.		120 to 132 in., excl.		132 in. or over.		
	Over.	Under.	Over.	Under.	Over.	Under.	Over.	Under.	Over.	Under.	Over.	Under.	Over.	Under.	Over.	Under.	Over.	Under.	
Under 5	5	3	5.5	3	6	3	7	3	...	...	...	...	...	...	...	...	...	...	Under 5
5 to 7.5 excl	4.5	3	5	3	5.5	3	6	3	...	...	...	...	...	...	...	...	...	...	5 to 7.5 excl.
7.5 " 10 "	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3	...	...	...	...	7.5 " 10 "
10 " 12.5 "	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3	9	3	10 " 12.5 "
12.5 " 15 "	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3	8	3	12.5 " 15 "
15 " 17.5 "	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	7	3	15 " 17.5 "
17.5 " 20 "	2.5	2	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	6	3	17.5 " 20 "
20 " 25 "	2	2	2.5	2	2.5	2.5	3	2.5	3.5	2.5	4	3	4.5	3	5	3	5.5	3	20 " 25 "
25 " 30 "	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3	4.5	3	5	3	25 " 30 "
30 " 40 "	2	2	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3	4.5	3	30 " 40 "
40 or over	2	2	2	2	2	2	2	2	2.5	2	2.5	2.5	3	2.5	3.5	3	4	3	40 or over

NOTE.—The weight per square foot of individual plates shall not vary from the ordered weight by more than 1⅓ times the amount given in this table.

TABLE II.—PERMISSIBLE OVERWEIGHTS OF PLATES ORDERED TO THICKNESS.

ORDERED THICKNESS, IN.	PERMISSIBLE EXCESS IN AVERAGE WEIGHTS PER SQUARE FOOT OF PLATES FOR WIDTHS GIVEN, EXPRESSED IN PERCENTAGES OF NOMINAL WEIGHTS.								ORDERED THICKNESS, IN.
	Under 48 in.	48 to 60 in., excl.	60 to 72 in., excl.	72 to 84 in., excl.	84 to 96 in., excl.	96 to 108in., excl.	108 to 120in., excl.	120 to 132in excl.	132 in or over.	
Under 1/8	9	10	12	14	..	..	..	..	..	Under 1/8
1/8 to 3/16 excl.	8	9	10	12	..	..	..	..	..	1/8 to 3/16 excl.
3/16 " 1/4 "	7	8	9	10	12	..	..	..	..	3/16 " 1/4 "
1/4 " 5/16 "	6	7	8	9	10	12	14	16	19	1/4 " 5/16 "
5/16 " 3/8 "	5	6	7	8	9	10	12	14	17	5/16 " 3/8 "
3/8 " 7/16 "	4.5	5	6	7	8	9	10	12	15	3/8 " 7/16 "
7/16 " 1/2 "	4	4.5	5	6	7	8	9	10	13	7/16 " 1/2 "
1/2 " 5/8 "	3.5	4	4.5	5	6	7	8	9	11	1/2 " 5/8 "
5/8 " 3/4 "	3	3.5	4	4.5	5	6	7	8	9	5/8 " 3/4 "
3/4 " 1 "	2.5	3	3.5	4	4.5	5	6	7	8	3/4 " 1 "
1 or over	2.5	2.5	3	3.5	4	4.5	5	6	7	1 or over

Rejection.

15. (*a*) Unless otherwise specified, any rejection based on tests made in accordance with Section 5 shall be reported within five working days from the receipt of samples.

(*b*) Material which shows injurious defects subsequent to its acceptance at the manufacturer's works will be rejected, and the manufacturer shall be notified.

Rehearing.

16. Samples tested in accordance with Section 5, which represent rejected material, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

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TENTATIVE SPECIFICATIONS FOR COMMERCIAL BAR STEELS.[1]

Serial Designation: A 80 – 20 T.

These specifications are issued under the fixed designation A 80; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1920.

Material Covered.

1. These specifications cover ordinary commercial carbon bar steels of grades considered to be in common use. The sections covered are rounds, squares and hexagons of all sizes, and flats not over 6 in. wide.

Basis of Purchase.

2. (*a*) Bars shall be hot-rolled or cold-finished, as specified.

(*b*) Cold-finished bars may be cold-rolled, cold-drawn, turned and polished, or turned and ground.

(*c*) The purchaser shall specify each grade desired by its grade designation or by its complete chemical limits.

I. MANUFACTURE.

Process.

3. The steel shall be made by the open-hearth or Bessemer process, as specified.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1921, to Mr. F. M. Waring, Chairman of Committee A-1 on Steel, Pennsylvania System, Altoona, Pa.

II. CHEMICAL PROPERTIES AND TESTS.

Chemical Composition.

4. The steel shall conform to the requirements as to chemical composition specified in Tables I and II for the respective grades.

Ladle Analyses

5. An analysis of each melt shall be made by the manufacturer to determine the percentages of the elements specified. This analysis shall be made from a test ingot taken during the pouring of the melt. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements for the grade specified in Table I.

TABLE I.—GRADES AND CHEMICAL COMPOSITIONS.

GRADES.	Carbon, per cent.	Manganese, per cent.	Phosphorus, per cent.	Sulfur, per cent.
OPEN-HEARTH GRADES.				
Open-hearth Dead Soft	0.05 – 0.12	0.55 max.	0.05 max.	0.06 max.
Open-hearth Soft	0.08 – 0.18	0.55 "	0.05 "	0.06 "
Open-hearth 15–25 Carbon	0.15 – 0.25	0.60 "	0.05 "	0.06 "
Open-hearth 20–30 Carbon	0.20 – 0.30	0.70 "	0.05 "	0.06 "
Open-hearth 25–40 Carbon	0.25 – 0.40	0.70 "	0.05 "	0.06 "
Open-hearth 35–50 Carbon	0.35 – 0.50	0.70 "	0.05 "	0.06 "
BESSEMER GRADES.				
Bessemer Welding	0.12 and under	0.60 max.	0.115 max.	0.08 max.
Bessemer Soft	0.15 and under	0.70 "	0.115 "	....
Bessemer 15–25 Carbon	0.15 – 0.25	0.90 "	0.115 "	....
Bessemer 25–40 Carbon	0.25 – 0.40	0.90 "	0.115 "	....
Bessemer 35–50 Carbon	0.35 – 0.50	0.90 "	0.115 "	....
Bessemer 40–60 Carbon	0.40 – 0.60	1.00 "	0.115 "	....
SCREW STEEL GRADES.				
Bessemer Screw	0.08 – 0.16	0.60 – 0.80	0.09 – 0.13	0.075 – 0.15
Open-hearth Screw	0.15 – 0.25	0.60 – 0.90	0.06 max.	0.075 – 0.15

TABLE II.—PERMISSIBLE VARIATIONS IN CHECK ANALYSES.

GRADES.	Permissible Variations from Limits Specified in Table I.				
	Carbon.		Manganese.	Phosphorus.	Sulfur.
	Under.	Over.	Over.	Over.	Over.
OPEN-HEARTH GRADES.					
Dead Soft and Soft	......	0.03	0.05	0.01	0.01
15-25 to 35-50 Carbon	0.02	0.05	0.10	0.01	0.01
BESSEMER GRADES.					
Welding and Soft	......	0.03	0.05	0.02	0.02
15-25 and 25-40 Carbon	0.02	0.05	0.10	0.02	.....
35-50 and 40-60 Carbon	0.05	0.08	0.10	0.02	....

Check Analyses.

6. (*a*) Analyses may be made by the purchaser from finished bars representing each melt of open-hearth steel, and

each melt, or lot of ten tons, of Bessemer steel. The chemical composition thus determined shall be considered acceptable within the permissible variations on check analyses specified in Table II.

(*b*) Samples for analysis shall be taken by machining off the entire cross-section of the bar, or by drilling parallel to the axis of the bar at any point midway between the center and surface.

TABLE III.—PERMISSIBLE VARIATIONS IN THE SIZES OF BARS.

HOT-ROLLED BARS.

Rounds, Squares and Hexagons: Sizes Specified.	Variations in Size, in.	
	Under.	Over.
Up to 1/2 in., incl.	0.007	0.007
Over 1/2 " 1 " "	0.010	0.010
" 1 " 2 " "	1/64	1/32
" 2 " 3 " "	1/32	3/64
" 3 " 5 " "	1/32	3/32
" 5 " 8 " "	1/16	1/8

Flats: Widths Specified.	Variations in Width, in.		Variations in Thickness, Under and Over, in., for Thicknesses Specified.			
	Under.	Over.	3/16 in. or Under.	Over 3/16 to 1/2 in., incl.	Over 1/2 to 1 in., incl.	Over 1 to 2 in., incl.
Up to 1 in., incl.	1/64	1/32	0.006	0.008	0.010	......
Over 1 " 2 " "	1/32	3/64	0.008	0.012	0.015	1/32
" 2 " 4 " "	3/64	1/16	0.010	0.015	0.020	1/32
" 4 " 6 " "	1/16	3/32	0.010	0.015	0.020	1/32

COLD-FINISHED BARS.

Sizes Specified.	Variations in Size, in.					
	Rounds and Hexagons.		Squares.		Flats: Width and Thickness.	
	Under.	Over.	Under.	Over.	Under.	Over.
Up to 0.3 in. incl.	1% of diameter	0	0.0025	0.0025	0.003	0.003
Over 0.3 " 1 " "	0.003	0	0.0025	0.0025	0.003	0.003
" 1 " 2 1/2 " "	0.004	0	0.004	0.004	0.004	0.004
" 2 1/2 in.	0.005	0	0.005	0.005	0.005	0.005

III. PERMISSIBLE VARIATIONS IN DIMENSIONS.

Permissible Variations.

7. The variation from the specified diameter, or distance between parallel faces, shall not exceed the limits specified in Table III.

IV. WORKMANSHIP AND FINISH.

Finish. 8. The material shall be free from injurious defects and shall have a workmanlike finish. Cold-finished bars shall have a bright smooth surface.

V. INSPECTION AND REJECTION.

Inspection. 9. The manufacturer shall afford the inspector representing the purchaser, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications.

Rejection. 10. Material which fails to conform to the above specifications will be rejected, and the manufacturer shall be notified.

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TENTATIVE SPECIFICATIONS
FOR
EXTRA REFINED WROUGHT-IRON BARS.[1]

Serial Designation: A 79 – 19 T.

These specifications are issued under the fixed designation A 79; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1919.

Material Covered.

1. These specifications cover all rectangular bars over ½ in. and not over 4 in. in thickness.

I. MANUFACTURE.

Process.

2. The iron shall be made wholly from all-pig puddled iron and shall be free from any admixture of iron scrap or steel.

Definition of Terms.

3. *Iron Scrap.*—This term applies only to foreign or bought scrap and does not include local mill products free from foreign or bought scrap.

II. PHYSICAL PROPERTIES AND TESTS.

Tension Tests.

4. (*a*) The iron shall conform to the following requirements as to tensile properties:

Tensile strength, lb. per sq. in.	48 000 – 54 000
Yield point, min., " "	0.6 tens. str.
Elongation in 8 in., min., per cent	25
Reduction of area, min., "	37

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1921, to Mr. J. B. Young, Secretary of Committee A-2 on Wrought Iron, Philadelphia and Reading Railway Co., Reading, Pa.

(*b*) The yield point shall be determined by the drop of the beam of the testing machine. The speed of the crosshead of the machine shall not exceed $\frac{3}{4}$ in. per minute.

Modifications in Tension Tests.

5. For material over 4 sq. in. in sectional area, the following deductions from the minimum requirements specified in Section 4 (*a*) shall be made for each square inch of nominal sectional area of material above 4 sq. in.:

Tensile strength..............	250 lb.,	but not under	46 000 lb.
Elongation..............	0.5 per cent,	" " "	22 per cent
Reduction of area........	1 "	" " "	32 "

Bend Tests.

6. (*a*) *Cold-bend Tests.*—Cold-bend tests will be made only on bars having a nominal sectional area of 4 sq. in. or under, in which case the test specimen shall bend cold through 180 deg. without fracture on the outside of the bent portion, around a pin the diameter of which is equal to the thickness of the specimen.

(*b*) *Hot-bend Tests.*—The test specimen, when heated to a temperature between 1700° and 1800° F., shall bend through 180 deg. flat on itself without fracture on the outside of the bent portion.

(*c*) *Nick-bend Tests.*—The test specimen, when nicked along one side with a tool having a 60-deg. cutting edge, to depth of not less than 8 nor more than 16 per cent of the thickness of the specimen, and broken, shall show a wholly fibrous fracture.

(*d*) Bend tests may be made by pressure or by blows.

Etch Tests.[1]

7. The cross-section of the test specimen shall be ground or polished, and etched for a sufficient period to develop the structure. This test shall show the material to be free from steel.

Test Specimens.

8. (*a*) Tension test specimens shall be of the full section of material as rolled, if possible. Otherwise, the specimen shall be machined from the material as rolled; the axis of the specimen shall be located at any point midway between the center and edge and shall be parallel to the axis of the bar.

(*b*) Bend and etch test specimens shall be of the full section of material as rolled.

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[1] A solution of two parts water, one part concentrated hydrochloric acid, and one part concentrated sulfuric acid is recommended for the etch test.

Number of Tests.

9. (*a*) Bars of one size shall be sorted into lots of 100 each. Two bars shall be selected at random from each lot or fraction thereof, and tested as specified in Sections 4 and 6; but only one of these bars shall be tested as specified in Section 7.

(*b*) If any test specimen from either of the bars originally selected to represent a lot of material contains surface defects not visible before testing but visible after testing, or if a tension test specimen breaks outside the middle third of the gage length, the individual bar shall be rejected and one retest from a different bar will be allowed.

III. PERMISSIBLE VARIATIONS IN GAGE.

Permissible Variations.

10. The width or thickness of bars shall not vary more than 2 per cent from that specified.

IV. FINISH.

Finish.

11. The bars shall be smoothly rolled and free from slivers, depressions, seams, crop ends, and evidences of being burnt.

V. MARKING.

Marking.

12. The bars shall be stamped or otherwise marked as designated by the purchaser.

VI. INSPECTION AND REJECTION.

Inspection.

13. (*a*) The inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. Tests and inspection at the place of manufacture shall be made prior to shipment.

(*b*) The purchaser may make the tests to govern the acceptance or rejection of material in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

(*c*) All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection.

14. (*a*) If either of the test bars selected to represent a lot does not conform to the requirements specified in Sections 4, 5, 6 and 7, the lot will be rejected.

(*b*) Unless otherwise specified, any rejection based on tests made in accordance with Section 13 (*b*) shall be reported within five working days from the receipt of samples.

(*c*) Bars which develop defects in forging or machining will be rejected, and the manufacturer shall be notified.

Rehearing

15. Samples tested in accordance with Section 13 (*b*), which represent rejected material, shall be preserved for two weeks from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

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TENTATIVE DEFINITIONS
OF
TERMS RELATING TO WROUGHT-IRON SPECIFICATIONS.[1]

Serial Designation: A 81 – 20 T.

These definitions are issued under the fixed designation A 81; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1920.

Puddling.—The process of making wrought iron by oxidizing and removing most of the silicon, carbon, manganese and phosphorus contained in pig iron in a reverberatory furnace. "Puddling" formerly was applied only to the practice of employing refined pig iron and "Pig Boiling" was the name applied when unrefined pig iron was used, but now this distinction is not generally made as the pig iron is seldom refined. Puddling as practiced to-day is really pig boiling.

Bushelling.—The process of heating to a welding heat in a reverberatory furnace, miscellaneous iron, steel or a mixture of iron and steel scrap cut into small pieces.

Fagoting.—The making of a "Fagot" or "Box" consisting of sides and bottom made of muck or scrap bar, the interior of which is filled with miscellaneous small iron scrap or a mixture of small iron and steel scrap.

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[1] Criticisms of these Tentative Definitions are solicited and should be directed, preferably before January 1, 1921, to Mr. J. B. Young, Secretary of Committee A-2 on Wrought Iron, Philadelphia and Reading Railway Co., Reading, Pa.

Muck Bar or Puddled Bar.—Bar rolled from puddled balls, made wholly from puddled pig iron.

Common Iron.—Iron made from rerolled scrap, no attempt being made to separate the iron and steel scrap.

Merchant Bar Iron.—Iron rolled from miscellaneous scrap, or from a box pile or fagot made of scrap bars and miscellaneous scrap or bushelled bars and miscellaneous scrap.

Refined Bar Iron or Refined Wrought-Iron Bars.—Iron rolled from muck bar pile, the muck bar being rolled from all puddled pig iron or rolled from a box pile of muck bars and wrought scrap free from steel; the bars to be the full length of the pile.

Double Refined Iron.—Iron made by cutting refined iron bars, piling them in either a slab pile or box pile, heating them them and rerolling into finished bars.

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TENTATIVE SPECIFICATIONS
FOR
NON-FERROUS ALLOYS FOR RAILWAY EQUIPMENT IN INGOTS, CASTINGS, AND FINISHED CAR AND TENDER BEARINGS.[1]

Serial Designation: B 17 - 18 T.

These specifications are issued under the fixed designation B 17; the final number indicates the year of original issue, or, in the case of revision, the year of last revision.

ISSUED, 1917; REVISED, 1918.

Material Covered.

1. (*a*) These specifications cover the various non-ferrous alloys for locomotive equipment in ingots, castings and finished car and tender bearings.

(*b*) These alloys and the purposes for which they are used are as follows:

Bearing Metal No. 1, for connecting-rod bearings, bushings, eccentric straps, crosshead gibs and miscellaneous bushings;

Bearing Metal No. 2, for driving-box bearings, engine-truck and trailer bearings, and hub liners;

Bearing Metal No. 3, for lead-lined bearings, for locomotive tenders, freight and passenger-car equipment;

Bell Metal, for locomotive bells only;

Babbitt Metal, for babbitting driving boxes, rod brasses, crossheads, and for hub liners;

Lining Metal, for lining truck brasses, tender brasses and car brasses.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1921, to Mr. William Campbell, Chairman of Committee B-2 on Non-Ferrous Metals and Alloys, Columbia University, New York City.

I. CHEMICAL PROPERTIES AND TESTS.

Chemical Composition

2. (*a*) The alloys shall conform to the following requirements as to chemical composition, with the permissible variations specified:

Alloy.	Copper, per cent.	Tin, per cent.	Lead, per cent.	Zinc, max., per cent.	Iron max., per cent.	Antimony, per cent.	Phosphorus, max., per cent.	Sulfur max, per cent.	Arsenic, max., per cent.	Total Impurities, including Zinc, max., per cent.
Bearing Metal No. 1....	remainder	9-11	9-11	0.75	0.25	0.25*a*	1.0*b*	....	....	1.0
Bearing Metal No. 2.....	remainder	4-6	22.5-26.5	0.75	0.40	0.50*a*	....	....	....	1.5
Bearing Metal No. 3......	remainder	4-6	17-22	2.50	0.40	0.50*a*	....	....	....	3.0
Bell Metal	remainder	16-18	0.25*a*	0.25	0.25	0.25*a*	0.02	0.05	....	0.50
Babbitt Metal	0.50*a*	9.25-10.75	remainder	none	....	14-16	....	....	0.20	0.75*c*
Lining Metal..	0.50*a*	4.50-5.50	remainder	none	....	9.25-10.75	....	....	0.20	0.75*c*

a Maximum.
b Not considered an impurity, and can be specified at option of purchaser.
c Must not contain zinc.

(*b*) Where no figures are given for impurity maximum, these elements may be present up to any amount to come within the total impurity specified, provided the material otherwise meets the chemical and physical tests. Where maximum percentages are specified, the elements referred to are considered as impurities and shall not be intentionally added.

Chemical Analysis.

3. An analysis will be made by the purchaser or his representative from one ingot, casting or journal bearing representing each lot. The chemical composition thus determined shall conform to the requirements specified in Section 2 for the particular alloy.

Sample for Chemical Analysis.

4. (*a*) *Ingots.*—Drillings shall be taken with a drill at least ½ in. in diameter at a point midway between the heaviest and smallest cross-section of the ingot. For ingots having two or more sections, drillings shall be taken from each section. In the case of Babbitt Metal and Lining Metal, drillings so taken shall be melted in a thoroughly cleaned ladle with a little rosin flux and poured into a piece of thin section. This piece shall be

sawed into three parts and the sawings therefrom thoroughly mixed to constitute the sample for chemical analysis.

(*b*) *Locomotive Castings.*—Drillings shall be taken with a drill as large as possible at such points in the casting as shall be thoroughly representative. Drillings through the skin shall be rejected. Drillings thoroughly mixed shall constitute the sample for chemical analysis.

(*c*) *Car and Tender Bearings.*—Drillings shall be taken with a drill at least ½ in. in diameter, at three points as widely separated as possible on the bearing selected for physical test as specified in Section 5 (*b*). Drillings representing the skin of the casting shall be rejected. These drillings, thoroughly mixed, shall constitute the sample for chemical analysis.

Drillings shall be taken in a like manner from the lining, exercising care that the drill does not penetrate the soldered surface.

(*d*) All samples, whether taken with a drill or saw, shall be kept free of oil and shall be carefully treated with a magnet to remove any iron introduced in taking the sample.

II. PHYSICAL INSPECTION AND TESTS.

Physical Inspection.

5. (*a*) *Locomotive Castings.*—The castings shall be sound, free from blowholes, flaws or shrinkage cracks, and shall show good foundry practice and workmanship.

One casting representing each lot of locomotive bearings will be broken by the purchaser or his representative for examination of fracture. The fracture shall disclose no shrink discoloration, segregation, dross or dirt spots within ⅝ in. of the bored journal engaging surface, and shall show no distinct signs of imperfect mixture.

(*b*) *Car and Tender Bearings.*—The bearings shall be sound, free from sand, blowholes, flaws or shrinkage cracks, and shall show good foundry practice and workmanship.

One bearing representing each lot will be broken by the purchaser or his representative for examination of fracture. The fracture shall show no shrink discoloration, segregation, dross or dirt spots within ½ in. of the bored journal engaging surface. This test shall be made before linings are applied. A second test shall be made after application of the lining as follows:

(1) The suspended brass when tapped with a hammer shall give a distinct ring.

(2) The lining when chipped with a cold chisel shall tear from the soldered surface as distinguished from clean shearing.

III. LOT.

Lot.

6. (*a*) *Ingots.*—Each 5000 lb. or fraction thereof shall constitute a lot. The ingot from which the sample is taken shall be included in the shipment.

(*b*) *Locomotive Castings.*—Unless otherwise specified, each 100 castings or fraction thereof shall constitute a lot.

The manufacturer shall furnish, free of cost, one casting representing each lot for purpose of tests as specified in Sections 4 (*b*) and 5 (*a*).

(*c*) *Car and Tender Bearings.*—Unless otherwise specified, each 300 bearings or fraction thereof from each pattern shall constitute a lot.

The manufacturer shall furnish, free of cost, one bearing representing each lot for purpose of tests as specified in Sections 4 (*c*) and 5 (*b*).

IV. PERMISSIBLE VARIATIONS IN DIMENSIONS.

(FOR CAR AND TENDER BEARINGS ONLY.)

Permissible Variations.

7. (*a*) The purchaser will furnish drawings showing the dimensions of the bearings ordered and permissible variations therefrom, and the bearings shall conform to these drawings within such permissible variations.

(*b*) The thickness at the center of the brass and of the complete bearing shall not vary more than $\frac{1}{32}$ in. over or under the normal thickness shown on the drawing. The thickness of the lining shall not vary more than $\frac{1}{32}$ in. over or under the normal thickness shown on the drawing.

V. WORKMANSHIP.

Workmanship.

8. (*a*) *Locomotive Castings.*—The castings shall conform to the dimensions specified and shall show good workmanship generally.

(*b*) *Car and Tender Bearings.*—The bearings shall show good workmanship generally, and shall be free from mechanical imperfections. They shall be bored to a true radius, and with the axis parallel to the plane of the top and perpendicular to the side lugs and bearing flange. The lettering shall be clear and distinct. No emery shall be used on journal engaging surfaces on either the brass or the lining.

VI. MARKING.

Marking. 9. (*a*) *Ingot.*—The manufacturer's marking only shall be required, unless otherwise specified.

(*b*) *Locomotive Castings.*—The lot number and other marks as required by the drawings shall be legibly marked on each casting.

(*c*) *Car and Tender Bearings.*—The name or initials of the manufacturer, the initials of the purchaser, type number, journal size, and lot number shall be legibly cast with raised figures on a depressed surface of each bearing, as shown on the drawings.

VII. INSPECTION AND REJECTION.

Inspection. 10. (*a*) Inspection may be made at the manufacturer's works where the ingots, locomotive castings or car and tender bearings are made, or at the point at which they are received, at the option of the purchaser.

(*b*) If the purchaser elects to have inspection made at the manufacturer's works, the inspector representing the purchaser shall have free entry at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 11. Failure to meet the chemical or physical specifications, or non-conformity to any of the above requirements as to permissible variations, dimensions and markings, constitute sufficient cause for rejection of the lot represented by the sample chosen.

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TENTATIVE SPECIFICATIONS
FOR
BRONZE BEARING METALS FOR TURNTABLES AND MOVABLE RAILROAD BRIDGES.[1]

Serial Designation: B 22 - 18 T.

These specifications are issued under the fixed designation B 22; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1918.

Material Covered.

1. (*a*) These specifications cover four classes of bronze bearing metals for turntables and movable railroad bridges.

(*b*) The purposes for which these classes are frequently used are as follows:

Class A, for contact with hardened steel disks under pressures over 1500 lb. per sq. in., for example, bearing metals, used in turntables and center-bearing swing bridges;

Class B, for contact with soft steel at low speeds under pressures not over 1500 lb. per sq. in., for example, trunnions and journals of bascule and lift bridges;

Class C, for ordinary machinery bearings;

Class D, for gears, worm wheels, nuts and similar parts which are subjected to other than compressive stresses.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1921, to Mr. William Campbell, Chairman of Committee B-2 on Non-Ferrous Metals and Alloys, Columbia University, New York City.

I. MANUFACTURE.

Process.

2. (*a*) The bronze shall be a homogeneous alloy of copper and tin. The copper shall conform to the requirements of the Standard Specifications for Electrolytic Copper Wire Bars, Cakes, Slabs, Billets, Ingots, and Ingot Bars (Serial Designation: B 5), or the Standard Specifications for Lake Copper Wire Bars, Cakes, Slabs, Billets, Ingots, and Ingot Bars, "high-resistance" grade (Serial Designation: B 4), of the American Society for Testing Materials.[1] The bronze shall be made from new metal, except that scrap of known composition produced by the foundry at which the bronze is cast may be used.

(*b*) Care shall be exercised that the metal is not overheated and that the temperature at pouring and the conditions of cooling are such as will be most likely to secure dense castings.

II. CHEMICAL PROPERTIES AND TESTS.

Chemical Composition.

3. The bronze shall conform to the following requirements as to chemical composition:

ELEMENTS CONSIDERED.	CLASS.			
	A	B	C	D
Copper, per cent	Remainder	Remainder	not over 82	not over 89
Tin, max., per cent	20	17	11	11
Lead, max., per cent	....	....	11	....
Zinc, max., per cent	....	....	....	2.25
Iron, max., per cent	....	....	....	0.2
Phosphorus, per cent	not over 1.0	not over 1.0	0.7 - 1.0	not over 0.25
Other elements, max., per cent	0.5	0.5	0.5	0.5

Chemical Analyses.

4. (*a*) An analysis of each melt may be made at the option of the purchaser and at the purchaser's expense. The chemical composition thus determined shall be reported to the purchaser or his representative, and shall conform to the requirements specified in Section 3.[2]

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[1] 1918 Book of A.S.T.M. Standards.

[2] Material with a range of composition differing from that specified in Section 3, or containing elements not specified, may be used, provided the manufacturer shall submit in writing previous to the execution of the contract the range of composition of the material he proposes to use, and provided this range of composition shall be accepted by the purchaser.

(*b*) The compression test coupon shall be used for analysis.

III. PHYSICAL PROPERTIES AND TESTS.

Compression and Tension Tests.

5. (*a*) The bronze shall conform to the following requirements as to compressive and tensile properties:

Properties Considered.	Class.			
	A	B	C	D
Compression.				
Deformation limit, min., lb. per sq. in. . .	24 000	18 000	. . . .	. . . .
Permanent set in 1 in. under 100 000 lb. per sq. in., in.	0.06 – 0.12	0.10 – 0.20	. . . .	. . . .
Tension.				
Yield point, min., lb. per sq. in.	. . . .	. . . .	. . . .	To be recorded
Tensile strength, min., lb. per sq. in. . . .	. . . .	. . . .	. . . .	33 000
Elongation in 2 in., min., per cent.	. . . .	. . . .	. . . .	14

(*b*) The deformation limit in compression shall be determined as that load which produces a permanent set of 0.001 in. in the compression test specimen described in Section 6 (*b*).

(*c*) The yield point in tension shall be determined as the stress producing an elongation under load of 0.5 per cent, that is, 0.01 in. in a gage length of 2 in.

Test Specimens.

6. (*a*) A test bar of the form and dimensions shown in Fig. 1, to be used for the tension test specimen, and a suitable test bar for the compression test specimen, shall be an integral part of the casting, and shall be fed and cooled under the same conditions as the castings.

(*b*) Compression test specimens shall be cylinders 1 sq. in. in cross-sectional area and 1 in. high.

(*c*) Tension test specimens, turned from the test bar shown in Fig. 1, shall conform to the dimensions shown in Fig. 2. The ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial.

Number of Tests.

7. (*a*) One compression test shall be made from each melt for Class A and B castings; and one tension test from each melt for Class D castings. For castings of any grade weighing over 100 lb. finished, the specified tests shall be made for each casting.

(*b*) If any test specimen shows defective machining or develops flaws, it may be discarded; in which case the manufacturer and the purchaser or his representative shall agree upon the selection of another specimen in its stead.

IV. FINISH.

Finish. 8. The castings shall be sound, clean, and free from blow holes, porous places, cracks and other defects.

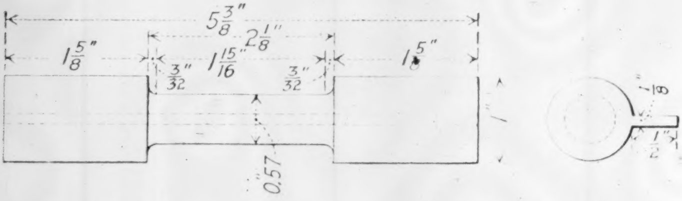
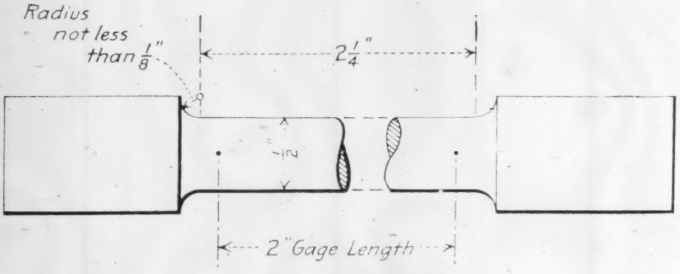

$5\frac{3}{8}''$
$2\frac{1}{8}''$
$1\frac{5}{8}''$
$1\frac{15}{16}''$
$\frac{3}{32}''$
$\frac{3}{32}''$
$1\frac{5}{8}''$
$1''$
0.57
$\frac{1}{8}$
$\frac{1}{2}''$

FIG. 1.


Radius not less than $\frac{1}{8}''$
$2\frac{1}{4}''$
$\frac{1}{2}$
2" Gage Length

Note:– The Gage Length, Parallel Portions and Fillets shall be as Shown, but the Ends may be of any Form which will Fit the Holders of the Testing Machine.

FIG. 2.

V. INSPECTION AND REJECTION.

Inspection. 9. (*a*) Inspection may be made at the manufacturer's works where the castings are made, or at the point at which they are received, at the option of the purchaser.

(*b*) If the purchaser elects to have inspection made at the manufacturer's works, the inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection.

10. Castings which show injurious defects revealed by machining operations subsequent to acceptance may be rejected, and if rejected, shall be replaced by the manufacturer free of cost to the purchaser. The full weight of the original material rejected shall be returned to the manufacturer.

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TENTATIVE SPECIFICATIONS
FOR
WHITE METAL BEARING ALLOYS

(KNOWN COMMERCIALLY AS "BABBITT METAL").[1]

Serial Designation: B 23 – 18 T.

These specifications are issued under the fixed designation B 23; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1918.

Material Covered. 1. These specifications cover white metal bearing alloys, known commercially as "babbitt metal." Twelve typical babbitt metals are specified, covering the range of alloys commercially used and are designated as Grades Nos. 1 to 12, in accordance with their decreasing tin content as specified in Section 4.

I. MANUFACTURE.

Uniform Quality. 2. The manufacturer shall use care to have each lot of babbitt metal as uniform in quality as possible.

Dimensions. 3. The standard bar, unless otherwise specified, shall have the following approximate dimensions:

Top face..........................	1¼ in. wide, 8½ in. long.
Thickness..........................	not over 1¼ in.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1921, to Mr. William Campbell, Chairman of Committee B-2 on Non-Ferrous Metals and Alloys, Columbia University, New York City.

II. CHEMICAL PROPERTIES AND TESTS.

Chemical Composition.

4. The alloys shall conform to the following requirements as to chemical composition, within the limits specified in Section 5:

Alloy, Grade No.	Tin, per cent.	Antimony, per cent.	Lead, per cent.	Copper, per cent.	Iron, max., per cent.	Arsenic, max., per cent.	Zinc, per cent.	Aluminum, per cent.
1........	91	4½	0.35[a]	4½	0.08	0.10	none	none
2........	89	7½	0.35[a]	3½	0.08	0.10	none	none
3........	83⅓	8⅓	0.35[a]	8⅓	0.08	0.10	none	none
4........	75	12	10	3	0.08	0.15	none	none
5........	65	15	18	2	0.08	0.15	none	none
6........	20	15	63½	1½	0.08	0.15	none	none
7........	10	15	75	0.50[a]	....	0.20	none	none
8........	5	15	80	0.50[a]	....	0.20	none	none
9........	5	10	85	0.50[a]	....	0.20	none	none
10........	2	15	83	0.50[a]	....	0.20	none	none
11........	..	15	85	0.50[a]	....	0.25	none	none
12........	..	10	90	0.50[a]	....	0.25	none	none

[a] Maximum.

Permissible Variations.

5. The following permissible variations in the percentages of the desired elements specified in Section 4 will be allowed, but shall not apply to the maximum percentages of impurities specified:

PERCENTAGE OF ELEMENT SPECIFIED.	PERMISSIBLE VARIATIONS OVER OR UNDER THE SPECIFIED VALUE, UNITS OF PER CENT.
Not over 2 per cent..................................	0.25
Over 2 to 5 per cent, incl..............................	0.50
Over 5 to 10 per cent, incl.............................	0.75
Over 10 per cent......................................	1.00

Samples for Chemical Analysis.

6. (*a*) Three bars shall be selected to represent a shipment of less than 1000 lb., five bars to represent a shipment of over 1000 lb. to 10,000 lb., inclusive, and ten bars to represent a shipment of over 10,000 lb. to one carload.

(*b*) Saw cuts shall be made at points in the bars indicated in Fig. 1. No lubricants shall be used for sawing. The sawings shall be carefully treated with a magnet to remove any particles of steel introduced in taking the sample.

(*c*) Sawings thoroughly mixed shall constitute the sample for chemical analysis.

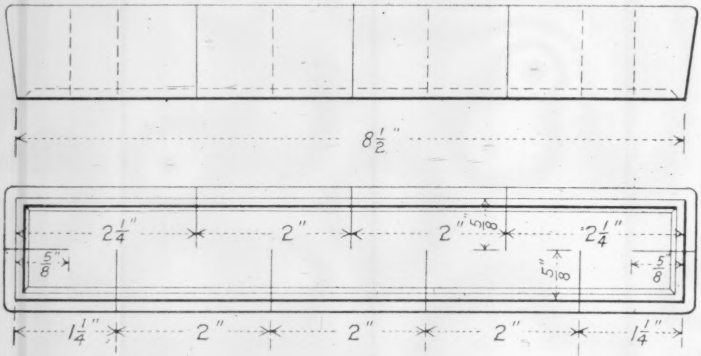
8½"
2¼"
2"
2"
2¼"
5/8"
5/8
5/16"
5/16"
1¼"
1¼"
2"
2"
2"
1¼"

FIG. 1.—Method of Sampling.

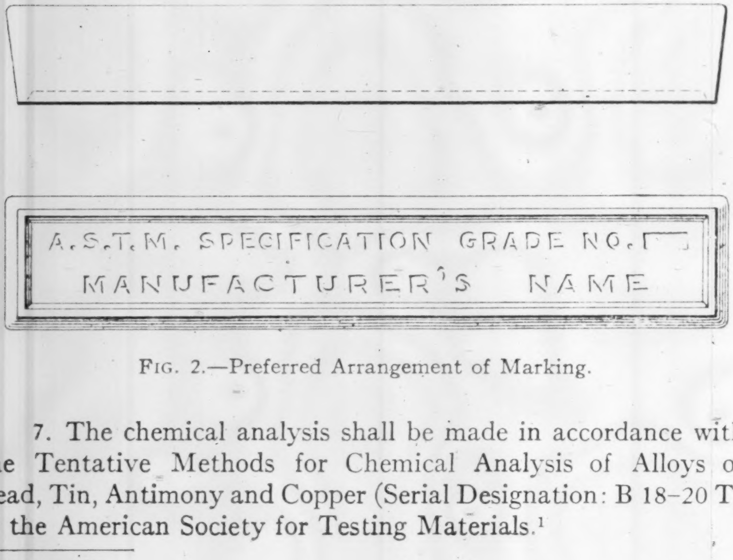
A.S.T.M. SPECIFICATION GRADE NO.
MANUFACTURER'S NAME

FIG. 2.—Preferred Arrangement of Marking.

Methods of Chemical Analyses. 7. The chemical analysis shall be made in accordance with the Tentative Methods for Chemical Analysis of Alloys of Lead, Tin, Antimony and Copper (Serial Designation: B 18–20 T) of the American Society for Testing Materials.[1]

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[1] See p. 589.

III. MARKING.

Marking.

8. The name of the manufacturer shall be cast on each bar. The numerical designation of the grade supplied shall be stamped or cast on each bar for identification.

NOTE.—A preferred arrangement of marking is shown in Fig. 2.

IV. CLAIMS.

Claims.

9. Claims, to be considered, shall be made in writing within thirty days of receipt of material at the purchaser's plant, and the results of the purchaser's tests shall be given. The shipper shall within one week of receipt of such claim, either agree to satisfy the claim or send a representative to the purchaser's plant to resample the shipment, as specified in Section 6. Samples so taken shall be sealed and submitted to a mutually agreeable umpire, whose determination shall be final.

Settlement of Claims.

10. The expense of umpire analysis shall be paid by the loser, or divided in proportion to the concession made in case of a compromise. In case of rejection being established, the damages shall be limited to the payment of freight both ways by the manufacturer for the substitution of an equivalent weight of babbitt metal meeting these specifications.

APPENDIX.

The data in the following table do not constitute a part of these specifications. They are given merely to indicate to the purchaser the physical properties of the various alloys specified which can be expected of carefully manufactured alloys of the formulas indicated, and to constitute a guide to the purchaser in selecting the grade best suited for meeting the service condition for which the babbitt metal is to be used. These figures are subject to revision.

TABLE SHOWING PHYSICAL PROPERTIES OF WHITE METAL BEARING ALLOYS.

Alloy No.	Formula.				Deformation of Cylinder $1\frac{1}{4}$ in. Diam. by $2\frac{1}{2}$ in. High at 70° F., in.			Brinell Hardness.		Melting Point.		Complete Liquation Point.		Specific Gravity.	Weight.		Proper Pouring Temperature, deg. Fahr.
	Copper, per cent.	Tin, per cent.	Antimony, per cent.	Lead, per cent.	At 1000 lb.	At 5000 lb.	At 10 000 lb.	At 70° F.	At 212° F.	Deg. Fahr.	Deg. Cent.	Deg. Fahr.	Deg. Cent.		Oz. per cu. in.	Grams per cu. in.	
1....	4.5	91.0	4.5	....	0.000	0.001	0.015	28.6	12.8	437.0	225	699.8	371	7.34	4.24	120.28	824
2....	3.5	89.0	7.5	....	0.0000	0.0015	0.0120	28.3	12.7	460.4	238	683.6	362	7.39	4.27	121.10	808
3....	$8\frac{1}{3}$	$83\frac{1}{3}$	$8\frac{1}{3}$	....	0.0010	0.0045	0.0070	34.4	15.7	462.2	239	791.6	422	7.46	4.31	122.25	916
4....	3.0	75.0	12.0	10.0	0.0005	0.0025	0.0090	29.6	12.8	365.0	185	555.8	291	7.52	4.35	123.23	680
5....	2.0	65.0	15.0	18.0	0.0010	0.0030	0.0090	29.6	11.8	365.0	185	536.0	280	7.75	4.48	127.00	661
6....	1.5	20.0	15.0	63.5	0.0015	0.0050	0.0180	24.3	11.1	365.0	185	512.6	267	9.33	5.39	152.89	638
7....	..	10.0	15.0	75.0	0.0010	0.0050	0.0230	24.1	11.7	464.0	240	500.0	260	9.73	5.62	159.44	625
8....	..	5.0	15.0	80.0	0.0020	0.0090	0.0620	20.9	10.3	469.4	243	500.0	260	10.04	5.80	164.52	625
9....	..	5.0	10.0	85.0	0.0040	0.0120	0.0840	19.5	8.6	469.4	243	491.0	255	10.24	5.92	167.80	616
10....	..	2.0	15.0	83.0	0.0010	0.0100	0.1540	17.0	8.9	473.2	245	500.0	260	10.07	5.82	165.02	625
11....	..	..	15.0	85.0	0.0010	0.0100	0.1190	17.0	9.9	476.8	247	500.0	260	10.28	5.94	168.46	625
12....	..	..	10.0	90.0	0.0025	0.0170	0.2850	14.3	6.4	476.8	247	509.0	265	10.67	6.17	174.85	634

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TENTATIVE SPECIFICATIONS FOR ALUMINUM INGOTS FOR REMELTING AND FOR ROLLING.[1]

Serial Designation: B 24 – 20 T.

These specifications are issued under the fixed designation B 24; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1918; REVISED, 1919, 1920.

Material Covered.

1. These specifications cover three grades of Virgin Aluminum, as follows:

GRADE.	ALUMINUM, PER CENT.
99.5	99.5 (Minimum)
99.0	99.0 (Minimum)
98.0	98.0 (Minimum)

Impurities.

2. The presence in any of the above grades of manganese, magnesium, zinc, calcium or similar metals commonly used in the light alloys, or of copper in excess of 0.1 per cent is not admissible, and such ingot cannot be classed as Virgin Aluminum under these specifications. Iron, silicon, and copper (not in excess of 0.1 per cent) are allowable impurities.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1921, to Mr. William Campbell, Chairman of Committee B-2 on Non-Ferrous Metals and Alloys, Columbia University, New York City.

I. MANUFACTURE.

Manufacture.

3. No scrap shall be used other than that resulting in the manufacturer's own plant from the production of material complying with these specifications, and which is of similar composition to the material specified.

II. PHYSICAL DEFECTS.

Physical Defects.

4. Ingots for rolling shall be of uniform quality, tough and sound. They shall be substantially free from blowholes, shrinkage cracks, cold-sets, dross, foreign matter, and other defects in set or casting. Such defects may be waived in ingots which are to be remelted.

III. SAMPLING.

Sampling.

5. If the aluminum is shipped in carload lots, then random samples shall be taken, but not less than five ingots for each car. If the shipment is in less than carload lots, one ingot shall be taken for each 10,000 lb. (4536 kg.) or fractional part thereof.

When it is deemed necessary, a sample may be taken from each heat of 500 lb. (226.8 kg.) or more of metal.

Drilling.

6. The ingots selected shall be drilled completely through, or half through from top and bottom. The drillings shall be fine, thin chips. They should be thoroughly mixed and the sample for analysis should not be less than 60 g.

IV. ANALYSES.

Analyses.

7. Analyses shall be made in accordance with standard method to be furnished by the committee.

V. MARKING.

Marking.

8. The maker's brand and the grade of aluminum shall be cast on each ingot. When this is not practicable, the grade shall be indicated by spotting each large ingot, or one ingot in each bundle of small ingots, with a designating color of paint: white indicating the 99.5 grade, blue, the 99.0 grade, and red, the 98.0 grade.

VI. CLAIMS.

Claims.

9. Claims, to be considered, shall be made in writing within ten days of receipt of material at the purchaser's plant, and the

results of the purchaser's tests shall be given. The vender shall within ten days of such claim, either agree to satisfy the claim or send a representative to the purchaser's plant to resample the shipment, as specified in Section 3. Samples so taken shall be sealed and submitted to a mutually agreeable umpire, whose determination shall be final.

Settlement of Claims.

10. The expense of the umpire analysis shall be paid by the loser, or divided in proportion to the concession made, in case of compromise. In case of rejection being established, the damage shall be limited to the payment of freight both ways by the vender for the substitution of an equivalent weight of metal meeting these specifications.

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TENTATIVE SPECIFICATIONS
FOR
ALUMINUM SHEET.[1]

Serial Designation: B 25 – 19 T.

These specifications are issued under the fixed designation B 25; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1918; REVISED, 1919.

I. MANUFACTURE.

Manufacture. 1. No scrap shall be used in the manufacture of aluminum sheet except such as shall accumulate at the manufacturer's own plant from material of the same composition and of his own manufacture.

II. CHEMICAL PROPERTIES AND TESTS.

2. The sheet may be rolled from aluminum ingots of Grade A, described in the Tentative Specifications for Aluminum Ingots for Remelting and for Rolling (Serial Designation: B 24–20 T) of the American Society for Testing Materials.[2]

Chemical Analyses. 3. Samples for analysis shall be obtained from a random sheet, representing each 500 lb. (226.8 kg.) of aluminum or any lot weighing less than 500 lb. (226.8 kg.), as agreed upon between the seller and the purchaser. Samples so prepared shall be divided into three equal parts, each of which shall be placed in a sealed package, one for each party and one for an umpire if necessary. The sample for analysis may be prepared by shearing.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1921, to Mr. William Campbell, Chairman of Committee B-2 on Non-Ferrous Metals and Alloys, Columbia University, New York City.

[2] See p. 543.

III. PHYSICAL PROPERTIES AND TESTS.

Tension Tests.

4. (*a*) Sheets may be furnished in either of three tempers or degrees of hardness and shall conform to the following requirements as to tensile properties:

TEMPER NO. 1; SOFT, ANNEALED.

B. & S. Gage.	Thickness, in.	Minimum Tensile Strength, lb. per sq. in.	Minimum Elongation in 2 in., per cent.
12 to 16, incl.	0.0808 – 0.0509	12 500	30
17 " 22, "	0.0508 – 0.0227	12 500	20
23 " 26, "	0.0226 – 0.0159	12 500	10

TEMPER NO. 2; HALF-HARD.

B. & S. Gage.	Thickness, in.	Minimum Tensile Strength, lb. per sq. in.	Minimum Elongation in 2 in., per cent.
12 to 16, incl.	0.0808 – 0.0509	18 000	7
17 " 22, "	0.0508 – 0.0227	18 000	5
23 " 26, "	0.0226 – 0.0159	18 000	5

TEMPER NO. 3; HARD.

B. & S. Gage.	Thickness, in.	Minimum Tensile Strength, lb. per sq. in.	Minimum Elongation in 2 in., per cent.
12 to 16, incl.	0.0808 – 0.0509	22 000	4
17 " 22, "	0.0508 – 0.0227	25 000	2
23 " 26, "	0.0226 – 0.0159	30 000	2

(*b*) The tension test specimen shall be taken parallel to the direction of cold rolling of the sheet.

Bend Tests.

5. Sheets of temper No. 1 shall withstand being bent double in any direction and hammered flat, and sheets of temper No. 2, being bent around a pin of radius equal to the thickness of the sheet, without cracking.

Number of Tests.

6. (*a*) One tension and one bend test specimen shall be cut from a random sheet representing each 500 lb. (226.8 kg.) of aluminum or any lot weighing less than 500 lb. (226.8 kg.), as agreed upon between the seller and the purchaser.

(*b*) Test specimens may be used for purposes of analysis specified in Section 3.

IV. PERMISSIBLE VARIATIONS IN DIMENSIONS.

Dimensional Variations.

7. The thickness of sheets shall not vary from that specified by more than the following amounts:

B. & S. Gage.	Thickness, in.	Permissible Variation, in.
10 to 17, incl.	0.1019 - 0.0404	0.003
18 " 26, "	0.0403 - 0.0159	0.002

V. WORKMANSHIP AND FINISH.

Workmanship.

8. All sheets shall be commercially flat and free from buckles; they shall be free from injurious surface defects and shall have a workmanlike finish.

VI. INSPECTION AND REJECTION.

Inspection.

9. The manufacturer shall afford the inspector representing the purchaser, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications.

Rejection.

10. Material which fails to conform to these specifications will be rejected and the manufacturer shall be notified.

EXPLANATORY NOTES.

Section 4.—Aluminum sheet cut in other directions than parallel to the direction of cold rolling will show a ductility less than that in this direction; the elongation at right angles to the direction of cold rolling may be only two-thirds of the former.

It is strongly recommended that a self-centering tension test specimen holder be used for testing particularly thin gages of hard aluminum sheet, in view of the lack of uniformity which may occur in test series made in the usual wedge grips.

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TENTATIVE SPECIFICATIONS
FOR
LIGHT ALUMINUM CASTING ALLOYS.[1]

Serial Designation: B 26 - 19 T.

These specifications are issued under the fixed designation B 26; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1918; REVISED, 1919.

Material Covered. 1. These specifications cover commercial light alloys of aluminum having a specific gravity of 3 and less.

I. MANUFACTURE.

Process. 2. The alloy may be made by any approved method.

II. CHEMICAL PROPERTIES AND TESTS.

Chemical Composition 3. The following alloys are described by these specifications; they shall conform to the following requirements as to chemical composition:

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1921, to Mr. William Campbell, Chairman of Committee B-2 on Non-Ferrous Metals and Alloys, Columbia University, New York City.

Alloy.	Copper, per cent.	Zinc, per cent.	Manganese, per cent.	Maximum Total Impurities, per cent.	Aluminum, per cent.
A	7 - 8.5	......	......	1.7	Remainder
B	8.5 - 11	......	......	1.7	Remainder
C	11 - 14	......	......	1.7	Remainder
D	2.5 - 3.0	12.5 - 14.5	......	1.7[a]	Remainder
E	2 - 2.5	......	0.75 - 1.25	1.0	Remainder

[a] Lead content shall not be greater than 0.1 per cent.

Sampling.

4. (*a*) The sample for chemical analysis may be taken either by sawing, drilling or milling the casting or tension test specimen and shall represent the average cross-section of the piece.

(*b*) The saw, drill, cutter or other tool used shall be thoroughly cleaned. No lubricant shall be used in the operation, and the sawdust or metal chips shall be carefully treated with a magnet to remove any particles of iron introduced in taking the sample.

III. PHYSICAL PROPERTIES AND TESTS.

Tension Tests.

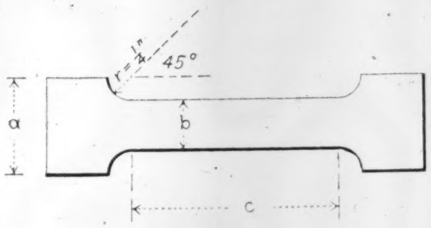
5. The alloys shall conform to the following minimum requirements as to tensile properties:

Alloy.	Minimum Tensile Strength, lb. per sq. in.	Minimum Elongation in 2 in., per cent.
A	18 000	1
B	18 000	..
C	19 000	..
D	25 000	1
E	18 000	8

Test Specimens.

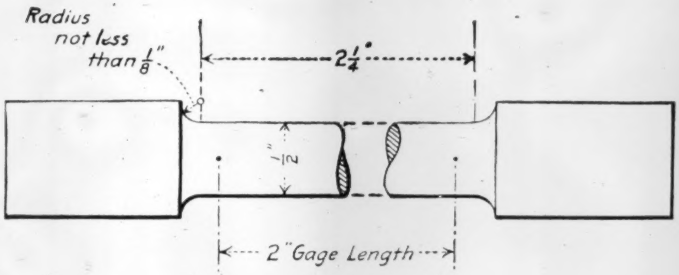
6. (*a*) Two test bars of the form and dimensions shown in Fig. 1 shall be an integral part of large castings, or cast separately in the case of small castings to represent a lot or melt, and shall be molded in a manner similar to the castings which they represent. If the castings are heat-treated, the test bars representing such castings shall be similarly heat-treated.

(*b*) The manufacturer and purchaser shall agree whether test bars can be attached to castings, on the location of the bars on the castings, on the castings to which bars are to be attached, and on the method of casting unattached bars.



a --- 1 in.
b --- not greater than $\frac{5}{8}$ in., nor less than $\frac{1}{2}$ in.
c --- not less than $2\frac{1}{8}$ in.

FIG. 1.



Note:- *The Gage Length, Parallel Portions and Fillets shall be as Shown, but the Ends may be of any Form which will Fit the Holders of the Testing Machine.*

FIG. 2.

(*c*) Tension test specimens, turned from the test bar shown in Fig. 1, shall conform to the dimensions shown in Fig. 2. The ends shall be of a form to fit the holders of the testing machine in such a way that the load shall be axial.

Number of Tests.

7. (*a*) Tests shall as far as possible be made by heats or melts, but unless otherwise agreed, two tension tests shall be made upon each unit lot of 500 lb. or single delivery of less than 500 lb.

(*b*) If any test specimen shows defective machining or develops flaws, it may be discarded; in which case the manufacturer and the purchaser or his representative shall agree upon the selection of another specimen in its stead.

IV. INSPECTION AND REJECTION.

Inspection. 8. (*a*) Inspection may be made at the manufacturer's works where the castings are made, or at the point at which they are received, at the option of the purchaser.

(*b*) If the purchaser elects to have inspection made at the manufacturer's works, the inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 9. Castings which show injurious defects revealed by machining operations subsequent to acceptance may be rejected, and if rejected, shall be replaced by the manufacturer free of charge to the purchaser. The full weight of the original material rejected shall be returned to the manufacturer.

EXPLANATORY NOTES.

The alloys described may be divided into two groups: those (A, B, C, D) having a relatively high hardness, as evidenced by the proportional limit, but little or no ductility; and E, which has a relatively low proportional limit, but a fair ductility. Thus the alloys A and D are quite suitable for general castings which, although highly stressed in service, will not likely be subjected to overstress. If a casting is likely to be subjected to a very rough treatment tending to overstress it, a more ductile alloy, E, is to be preferred.

Alloys B and C are suitable for high temperature and pressure service. Alloy B is recommended for pistons, alloy C for manifolds, carburetors, pumps, etc. Average values for other physical properties of these alloys are given in the following table:

PHYSICAL PROPERTIES OF ALUMINUM ALLOYS.

Alloy.	Density, g. per cc.	Shrinkage, in. per ft.	Temperature, Melting Range.		Proportional Limit, lb. per sq. in.
			Deg. Cent.	Deg. Fahr.	
A	2.89	0.156	637 - 540	1146 - 972	about 10 000
B	2.95	0.156	630 - 540	1133 - 972	....
C	3.00	0.156	623 - 540	1120 - 972	....
D	3.00	0.156	625 - 440	1124 - 792	....
E	2.79	0.156	649 - 529	1166 - 952	less than 2 000

Section 5.—The elongations obtained with Alloys B, C and D are generally less than 1 per cent and are too small to be satisfactorily measured.

Section 6.—Some latitude has been allowed in the diameter of the cast test bars; test bars cast to size are stronger than those which are machined, and the tensile properties specified can be obtained under usual conditions only with the cast-to-size bar.

It is strongly recommended that a self-centering form of tension test specimen holder be used. Most aluminum alloys (A, B, C, D) are brittle and give lower and less uniform test results when tested in ordinary wedge grips without centering.

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TENTATIVE SPECIFICATIONS

FOR

PIG LEAD.[1]

Serial Designation: B 29 – 20 T.

These specifications are issued under the fixed designation B 29; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1919; REVISED, 1920.

Definition. 1. Virgin Lead is lead made from ore or similar raw material by direct processes of reduction and refining, and not produced from reworked metal, and is termed Pig Lead.

Grades. 2. Under these specifications Virgin Lead is considered in three grades, as follows:

I. Corroding Lead.
II. Chemical Lead.
III. Common Lead.

I. MANUFACTURE.

Uniform Quality. 3. The maker shall use care to have each carload of as uniform quality as possible.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1921, to Mr. William Campbell, Chairman of Committee B-2 on Non-Ferrous Metals and Alloys, Columbia University, New York City.

II. CHEMICAL PROPERTIES AND TESTS.

(*A*) *Chemical Composition.*

Corroding Lead.

4. Corroding Lead (Grade I) shall conform to the following requirements as to chemical composition:

Silver	not over	0.0015	per cent.
Copper	" "	0.0015	"
Copper and silver together	" "	0.0025	"
Arsenic	" "	0.0015	"
Antimony and Tin together	" "	0.0095	"
Zinc	" "	0.001	"
Iron	" "	0.002	"
Bismuth	" "	0.05	"
Lead (by difference)		99.9335	"

Chemical Lead.

5. Chemical Lead (Grade II) shall conform to the following requirements as to chemical composition:[1]

Copper		0.04 – 0.10	per cent.
Bismuth	not over	0.005	"
Total Impurities other than Copper	" "	0.05	"

Common Lead.

6. Common Lead (Grade III) shall conform to the following requirements as to chemical composition:

(*a*) *Desilverized Lead:*

Silver	not over	0.002	per cent.
Copper	" "	0.0025	"
Arsenic, Antimony and Tin together	" "	0.015	"
Bismuth	" "	0.35	"
Iron	" "	0.002	"
Zinc	" "	0.002	"
Lead (by difference)		99.6265	"

(*b*) *Soft Missouri Lead:*[2]

Silver	not over	0.002	per cent.
Copper	" "	0.04	"
Arsenic, Antimony and Tin together	" "	0.015	"
Bismuth	" "	0.005	"
Iron	" "	0.005	"
Zinc	" "	0.002	"
Lead (by difference)		99.931	"

(*B*) *Sampling and Analysis.*

Sampling.

7. (*a*) In sampling, a carload or less shall be considered a lot or unit. One pig shall be taken to represent each ton of

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[1] This composition represents present requirements in the United States.

[2] Soft Missouri Lead is a trade name used to cover soft undesilverized lead.

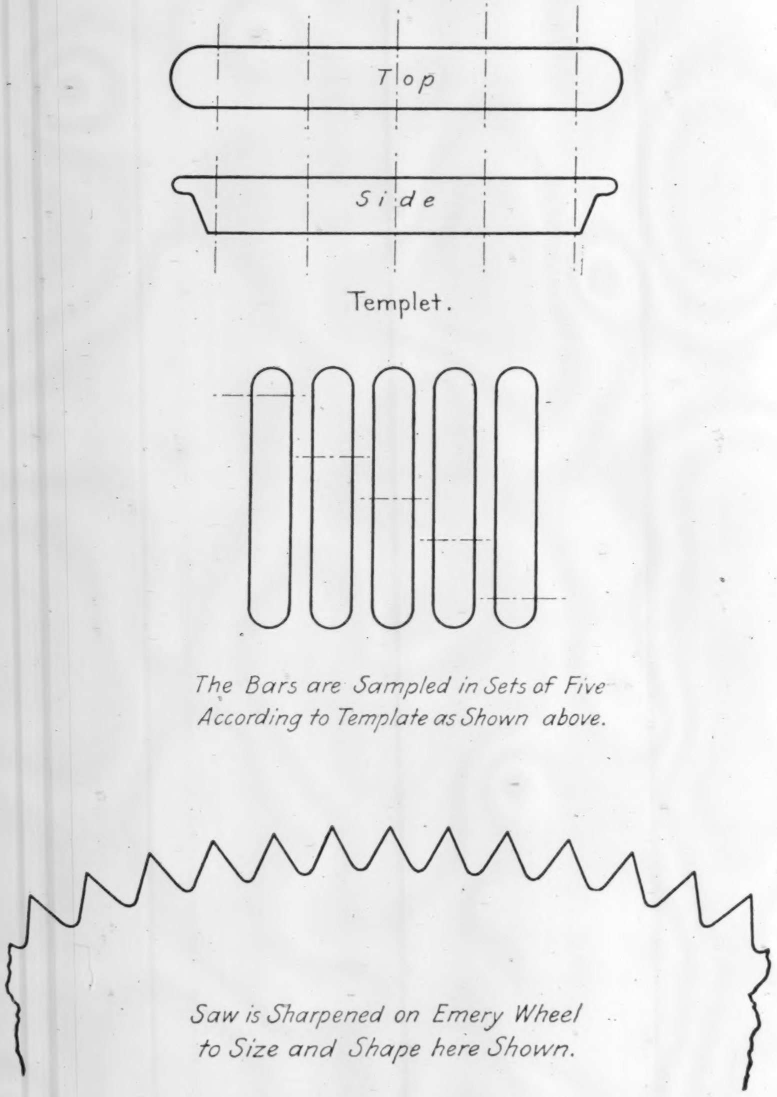
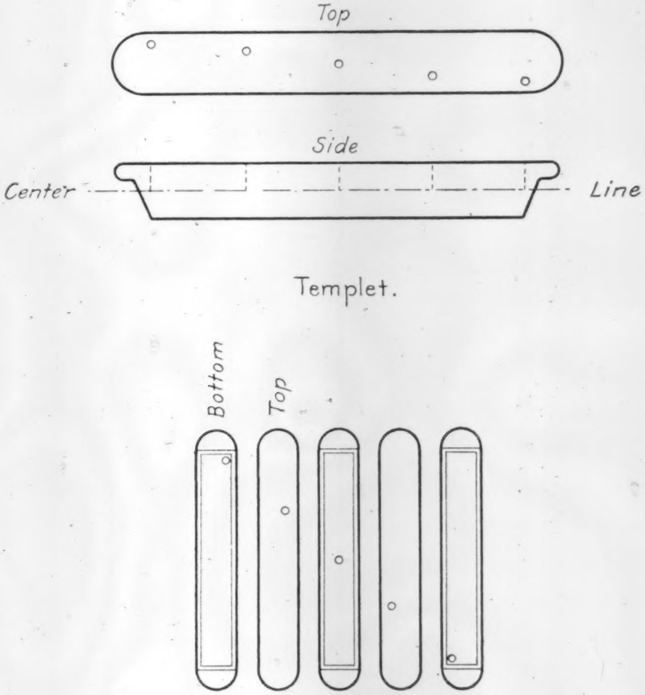

Top
Side
Templet.
The Bars are Sampled in Sets of Five
According to Template as Shown above.
Saw is Sharpened on Emery Wheel
to Size and Shape here Shown.

FIG. 1.—Saw Method of Sampling Lead.

lead in the lot. The pigs thus taken shall be sampled by one of the following methods:

1. By sawing completely through, as illustrated in Fig. 1;



The Bars Selected as Samples are Placed in a Line with every other Bar, Bottom Side up. The Sampling is Done according to Template in Sets of five Bars each, as Indicated above. The Punch must be Driven Halfway through the Bar. In Case a Larger Sample is Desired, the Bars are Turned over and Sampled on the other Diagonal.

FIG. 2.—Punch Method of Sampling Lead.

2. By punching completely through (if equipment permits) or punching half-way through from two opposite sides, as illustrated in Figs. 2 and 3;
3. By drilling at least half-way through.

(*b*) Whenever the surface of the pigs to be sampled is dirty, care shall be taken to see that none of the dirt or foreign material gets into the sample.

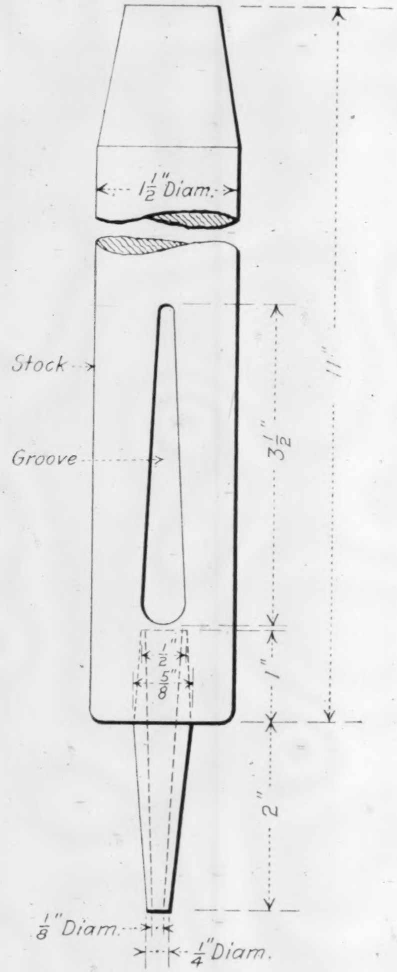


FIG. 3.—Sample Punch for Lead.

Sawing. 8. If the sample is taken by sawing, the sawdust from all the pigs shall be thoroughly mixed and quartered and the sample for analysis drawn from the mixed material. Care shall be taken that the sawdust is free from all extraneous material.

Punching or Drilling. 9. If the sample is taken by punching or drilling, the holes shall be spaced along a diagonal line from one corner of the pig to the other. Sampling in this manner may be so arranged that one or more holes are made in each of several pigs of a group in such positions that they represent consecutive positions on the diagonal of a single pig. (See illustration in Fig. 2.)

(*a*) If punchings are taken, they may be carefully melted in a clean graphite crucible, and either granulated by carefully pouring into distilled water and thoroughly drying, or casting into thin slabs which shall be sawed completely through in several places and the sawdust treated as described in Section 8.

(*b*) If drillings are taken, they may be clipped and mixed, and the sample for analysis drawn from the mixed material; or they may be melted as in the case of punchings.

Methods of Chemical Analysis. 10. The chemical analysis shall be made in accordance with the Standard Methods for Chemical Analysis of Pig Lead (Serial Designation: B 35) of the American Society for Testing Materials.[1]

III. MARKING.

Marking. 11. A brand shall be cast or otherwise plainly marked upon each pig by which the maker and grade may be identified.

IV. CLAIMS.

Claims. 12. (*a*) Claims, to be considered, shall be made in writing within 30 days of receipt of the material at the purchaser's plant, and the results of the purchaser's tests shall be given. The seller shall be given one week from date of receipt of such claim to investigate his records, and then shall agree either to satisfy the claim or to the submission of samples to an umpire. No claim shall be considered unless the sample pigs can be shown to the seller's representative.

(*b*) Where the lead satisfies the purity requirements of these specifications, it shall not be condemned for defects in the products in which it is used.

Investigation of Claims. 13. On questions of purity a sample shall be drawn by representatives of both parties, as described under "Sampling." The properly mixed and quartered sample shall be separated into three parts, each of which shall be placed in a sealed package, one for each party and one for an umpire, if necessary. Each party shall make an analysis, and if the results do not establish or dismiss the claim to the satisfaction of both parties, the third sample shall be submitted to a mutually agreeable umpire, who shall determine the question of quality, and whose determination shall be final.

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[1] A.S.T.M. Standards Adopted in 1920.

Settlement of Claims.

14. The expense of the seller's representative and of the umpire shall be paid by the loser, or divided in proportion to the concession made in case of compromise. In case of rejection being established, damages shall be limited to the payment of freight both ways by the seller for substitution of an equivalent weight of lead meeting these specifications.

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TENTATIVE SPECIFICATIONS
FOR
BRASS INGOT METAL FOR SAND CASTINGS.[1]

Serial Designation: B 30 – 19 T.

These specifications are issued under the fixed designation B 30; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1919.

Material Covered.

1. These specifications cover brass ingot metal for sand castings, known commercially as red and yellow brass ingot, made wholly or partly from scrap materials. Seven typical alloys are specified and are designated Grades Nos. 1 to 7, in accordance with their decreasing copper content as specified in Section 3.

I. MANUFACTURE.

Uniform Quality.

2. The manufacturer shall use care to have each lot of ingot metal as uniform in quality as possible.

II. CHEMICAL PROPERTIES AND TESTS.

Chemical Composition.

3. The alloys shall conform to the following requirements as to chemical composition, within the limits specified in Section 4:

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1921, to Mr. William Campbell, Chairman of Committee B-2 on Non-Ferrous Metals and Alloys, Columbia University, New York City.

Alloy, Grade No.	Copper, per cent.	Tin, per cent.	Lead, per cent.	Zinc, per cent.	Iron, max., per cent.	Antimony, max., per cent.	Aluminum, per cent.	Sulfur, max., per cent.
1	86	8	3[a]	3	0.25	0.25	none	0.05
2	85	5	5	5	0.35	0.25	none	0.05
3	83	4	6	7	0.35	0.25	none	0.05
4	77	3	10	10	0.40	0.35	none	0.05
5	76	2	6	16	0.40	0.25	none	0.05
6	65	1[a]	2	33	0.50	0.20	none[1]	0.05
7	60	1½[a]	3	37	1.00	0.20	none[1]	0.05

[a] Maximum. [1] See Appendix.

Permissible Variations.

4. The following permissible variations in the percentages of the desired elements specified in Section 3 will be allowed, but shall not apply to the maximum percentages of impurities specified:

PERCENTAGE OF ELEMENT SPECIFIED.	PERMISSIBLE VARIATIONS OVER AND UNDER THE SPECIFIED VALUE, UNITS OF PER CENT.
Not over 5 per cent	0.50
Over 5 to 10 per cent, incl	0.75
Over 10 per cent	1.00

Samples for Chemical Analysis.

5. (*a*) Three ingots shall be selected by the inspector to represent 10,000 lb. of ingot or fraction thereof.

(*b*) The samples for chemical analysis may be taken either by sawing, drilling or milling the ingots and shall represent the average cross-section.

(*c*) The saw, drill, cutter or other tool used shall be thoroughly cleaned. No lubricant shall be used in the operation, and the sawings or metal chips shall be carefully treated with a magnet to remove any particles of steel introduced in taking the sample.

Methods of Chemical Analysis.

6. To be prepared by the Committee.

III. MARKING.

Marking.

7. The designating mark of the manufacturer, the proper lot number, and the numerical designation of the grade supplied shall be marked on each ingot for identification.

IV. INSPECTION AND REJECTION.

Inspection.

8. (*a*) Inspection may be made at the manufacturer's works where the ingots are made, or at the point at which they are received, at the option of the purchaser.

(*b*) If the purchaser elects to have inspection made at the manufacturer's works, the inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection.

9. If the test ingots selected to represent a lot fail to conform to the requirements specified in Sections 3 and 4, all ingots in such lot will be rejected.

V. CLAIMS.

Claims.

10. Claims, to be considered, shall be made in writing within thirty days of receipt of material at the purchaser's plant, and the results of the purchaser's tests shall be given. The shipper shall within one week of receipt of such claim, either agree to satisfy the claim or send a representative to the purchaser's plant to resample the shipment, as specified in Section 5. Samples so taken shall be sealed and submitted to a mutually agreeable umpire, whose determination shall be final.

Settlement of Claims.

11. The expense of umpire analysis shall be paid by the loser or divided in proportion to the concession made in case of a compromise. In case of rejection being established, the damages shall be limited to the payment of freight both ways by the manufacturer for the substitution of an equivalent weight of ingot metal meeting these specifications.

APPENDIX.

The data in the following table do not constitute a part of these specifications. They are given merely to indicate to the purchaser the physical properties of the various alloys specified which can be expected of carefully manufactured alloys of the formulas indicated, and to constitute a guide to the purchaser in selecting the grade best suited for meeting the service condition for which the ingot metal is to be used.

TABLE SHOWING PHYSICAL PROPERTIES OF BRASS INGOT METAL ALLOYS.

Alloy, Grade No.	Desired Composition.				Tensile Strength, lb. per sq. in.[1]	Elongation, in 2 in., per cent.[1]	Reduction of Area, per cent.[1]	Brinell Hardness (500 kg. for 30 sec.).	Shrinkage, in. per ft.	Weight, lb. per cu. in.
	Copper, per cent.	Tin, per cent.	Lead, per cent.	Zinc, per cent.						
1	86	8	3	3	30-36 000	25-30	25-30	....	0.125	0.31
2	85	5	5	5	27-33 000	16-20	15-20	50-60	0.14	0.31
3	83	4	6	7	28-33 000	15-20	20-26	55-60	0.125	0.31
4	77	3	10	10	23-28 000	10-15	10-15	50-55	0.125	0.32
5	76	2	6	16	25-30 000	20-30	20-30	43-48	0.18	0.31
6	65	...	2	33	25-30 000	20-30	25-35	37-42	0.18	0.30
7	60	...	3	37	30-45 000	15-25	20-30	43-48	0.20	0.29

[1] The tension tests were made on "sand cast-to-size" test specimens.

Grade No.	Example of Uses.	Foundry Manipulation.	Characteristics.
1	High grade steam metal	Easily handled	Machines well.
2	High grade red brass for general service	Easily handled	Machines more readily than No 1.
3	Medium grade red brass for general service	Easily handled	Machines more readily than No. 1.
4	Small valves and fittings	Not difficult	Machines very easily.
5	Reddish yellow alloy, for air, gas and water fittings.	Not difficult	Machines very easily.
6	Yellow brass for general service	Difficult. Aluminum up to 0.3 per cent improves casting properties, but increases shrinkage.	Machines poorly. Not suitable for bearings or water pressure fittings.
7	Plumbers' flanges, scupper pipes, etc	Very difficult. Aluminum up to 0.3 per cent improves casting properties, but increases shrinkage.	Hard to machine. Not suitable for bearings or water pressure fittings.

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TENTATIVE SPECIFICATIONS
FOR
BRONZE BEARING METAL IN INGOT FORM.[1]

Serial Designation: B 31 – 19 T.

These specifications are issued under the fixed designation B 31; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1919.

1. These specifications cover copper- tin- lead alloys in ingot form, known commercially as "bronze bearing metal," made wholly or partly from scrap materials. Six typical alloys are specified and are designated as Grades Nos. 1 to 6, in accordance with their decreasing copper content as specified in Section 3. **Material Covered.**

I. MANUFACTURE.

2. The manufacturer shall use care to have each lot of bronze bearing metal as uniform in quality as possible. **Uniform Quality.**

II. CHEMICAL PROPERTIES AND TESTS.

3. The alloys shall conform to the following requirements as to chemical composition, within the limits specified in Section 4: **Chemical Composition.**

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1921, to Mr. William Campbell, Chairman of Committee B-2 on Non-Ferrous Metals and Alloys, Columbia University, New York City.

Alloy, Grade No.	Copper, per cent.	Tin, per cent.	Lead, per cent.	Zinc, max., per cent.	Phosphorus per cent.	Sulfur, max., per cent.	Iron, max., per cent.	Antimony, max., per cent.	Aluminum, per cent.	Total Impurities, max., per cent.
1.......	85	10	5	0.25	0.70[a]	0.05	0.25	0.50	none	0.50
2.......	80	10	10	0.50	0.70[a]	0.05	0.25	0.50	none	0.75
3.......	80	10	10	2.00	0.05[b]	0.05	0.25	0.50	none	2.50
4.......	77	8	15	0.50	0.25[b]	0.05	0.25	0.50	none	0.75
5.......	73	7	20	0.50	0.05[b]	0.25	0.25	0.50	none	1.00
6.......	70	5	25	0.50	none	0.25	0.25	0.50	none	1.00

[a] Minimum. [b] Maximum.

Permissible Variations.

4. The following permissible variations in the percentages of the desired elements specified in Section 3 will be allowed, but shall not apply to the maximum percentages of impurities specified:

PERCENTAGE OF ELEMENT SPECIFIED.	PERMISSIBLE VARIATIONS OVER AND UNDER THE SPECIFIED VALUE, UNITS OF PER CENT.
Not over 5 per cent	0.50
Over 5 to 10 per cent, incl	0.75
Over 10 per cent	1.50

Samples for Chemical Analysis.

5 (*a*). Three ingots shall be selected by the inspector to represent 10,000 lb. of ingot or fraction thereof.

(*b*) The samples for chemical analysis may be taken either by sawing, drilling or milling the ingots and shall represent the average cross-section.

(*c*) The saw, drill, cutter or other tool used shall be thoroughly cleaned. No lubricant shall be used in the operation, and the sawings or metal chips shall be carefully treated with a magnet to remove any particles of steel introduced in taking the sample.

Methods of Chemical Analysis.

6. Methods of chemical analysis to be prepared by the committee.

III. MARKING.

Marking.

7. The designating mark of the manufacturer, the proper lot number, and the numerical designation of the grade supplied shall be marked on each ingot for identification.

IV. INSPECTION AND REJECTION.

8. (*a*) Inspection may be made at the manufacturer's works where the ingots are made, or at the point at which they are received, at the option of the purchaser. **Inspection.**

(*b*) If the purchaser elects to have inspection made at the manufacturer's works, the inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

9. If the test ingots selected to represent a lot fail to conform to the requirements specified in Sections 3 and 4, all ingots in such lot will be rejected. **Rejection.**

V. CLAIMS.

10. Claims, to be considered, shall be made in writing within thirty days of receipt of material at the purchaser's plant, and the results of the purchaser's tests shall be given. The shipper shall within one week of receipt of such claim, either agree to satisfy the claim or send a representative to the purchaser's plant to resample the shipment, as specified in Section 5. Samples so taken shall be sealed and submitted to a mutually agreeable umpire, whose determination shall be final. **Claims.**

11. The expense of umpire analysis shall be paid by the loser or divided in proportion to the concession made in case of a compromise. In case of rejection being established, the damages shall be limited to the payment of freight both ways by the manufacturer for the substitution of an equivalent weight of bronze bearing metal meeting these specifications. **Settlement of Claims.**

APPENDIX.

The data in the following table do not constitute a part of these specifications. They are given merely to indicate to the purchaser the physical properties of the various alloys specified which can be expected of carefully manufactured alloys of the formulas indicated, and to constitute a guide to the purchaser in selecting the grade best suited for meeting the service condition for which the bronze bearing metal is to be used.

TABLE SHOWING PHYSICAL PROPERTIES OF BRONZE BEARING METAL ALLOYS.

Alloy, Grade No.	DESIRED COMPOSITION.			Ultimate Tensile Strength, lb. per sq. in.[1]	Elongation, in 2 in., per cent.[1]	Brinell Hardness (500 kg. for 30 sec.)	Shrinkage, in. per ft.	Weight, lb. per cu. in.	Compression, Elastic Limit, lb. per sq. in.[2]
	Copper, per cent.	Tin, per cent.	Lead, per cent.						
1..........	85	10	5	28 000	12.5	60	0.25	0.31	18 000
2..........	80	10	10	25 000	8	55	0.25	0.31	15 000
3..........	80	10	10	22 000	8	50	0.25	0.32	12 500
4..........	77	8	15	20 000	10	48	0.25	0.33	12 000
5[a]..........	73	7	20	18 000	7	45	0.25	0.33	11 000
6[a]..........	70	5	25	15 000	5	40	0.25	0.33	10 000

[a] More difficult to handle in the foundry than the other grades on account of the segregation of lead. Can be improved by the addition of 1 per cent of nickel.

[1] The tension tests were made on "sand cast-to-size" test specimens.

[2] The compression tests were made on machined test specimens (sand castings) of 1 sq. in. sectional area, 1 in. high. The elastic limit is taken as the load producing a compression in the specimen of 0.001 in.

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TENTATIVE SPECIFICATIONS
FOR
SOLDER METAL.[1]

Serial Designation: B 32 – 19 T.

These specifications are issued under the fixed designation B 32; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1919.

Material Covered.

1. (*a*) These specifications cover lead-tin alloys used for solder metal and commercially known as soft solder.

(*b*) Two classes, A and B, are given, in each of which several compositions are specified, covering the range of alloys commercially used and designated as Grades Nos. 0 to 5, in accordance with their decreasing tin content as specified in Section 4.

The choice of the class and grade of solder for any specified purpose depends on the material in connection with which it is to be used and the method of applying. For galvanized iron and zinc, only Class A should be used. Recommended practice is given in an appendix to these specifications, together with a table showing melting points to constitute a guide to the purchaser in selecting the grade best suited for meeting the conditions required.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably, before January 1, 1921, to Mr. William Campbell, Chairman of Committee B-2 on Non-Ferrous Metals and Alloys, Columbia University, New York City.

I. MANUFACTURE.

Uniform Quality.

2. The manufacturer shall use care to have each lot of solder metal as uniform in quality as possible. Each bar, ingot, or other form in which the solder is sold shall be uniform in composition with the entire lot. All grades in Class A shall be made from new or virgin metals. All grades in Class B shall be made from at least one-half new or virgin metals, the balance being recovered or secondary metals.

Dimensions.

3. When specified in bar or ingot form, the sizes or shapes, unless otherwise specified, shall be approximately as follows:

			Length, in.	Width, in.	Thickness, in.
A	Bar	Top	13½	¾	⅜
		Bottom	13½	⅝	
B	Ingot	Top	5½	2½	1½
		Bottom	4½	1½	

II. CHEMICAL PROPERTIES AND TESTS.

Chemical Composition.

4. The alloys shall conform to the following requirements as to chemical composition, within the limits specified in Section 5:

Grade No.	Tin, per cent.	Lead, Approx., per cent.	Antimony, max., per cent.	Copper, max., per cent.	Zinc and Aluminum, per cent.	Other Impurities,[1] max., per cent.
CLASS A.						
0	63.00	37.00	0.12	0.08	none	0.10
1	50.00	50.00	0.12	0.08	none	0.10
2	45.00	55.00	0.12	0.08	none	0.10
3	40.00	60.00	0.12	0.08	none	0.10
4	37.50	62.50	0.12	0.08	none	0.10
5	33.00	67.00	0.12	0.08	none	0.10
CLASS B.						
1	49.25	50.00	0.75	0.15	none	0.10
2	43.50	55.00	1.50	0.15	none	0.10
3	38.00	60.00	2.00	0.15	none	0.10
4	35.50	62.50	2.00	0.15	none	0.10
5	31.00	67.00	2.00	0.15	none	0.10

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[1] Exclusive of Bismuth.

Permissible Variations. 5. The permissible variation plus or minus in the percentage of tin shall not be over 1 per cent of the tin contents specified in Section 4.

Sample for Chemical Analysis. 6. (*a*) Three bars or ingots shall be selected to represent a shipment of less than 1000 lb., five bars or ingots to represent a shipment of over 1000 lb. to 10,000 lb., inclusive, and ten bars or ingots to represent a shipment of over 10,000 lb. to one carload. In case the shipment is in other form, such as wire, wire segments, drops, pigs or slabs, an equivalent amount of metal representative of the lot shall be taken, but in no case shall less than one whole piece (except wire) represent a shipment.

(*b*) The preferable method of preparing the sample for chemical analysis is to cut exactly in half the bars selected, marking each half and retaining one of each of the half bars to preserve their identity and for check analysis. The remaining half of each bar shall then be remelted in a perfectly clean utensil at a temperature a little above the complete liquation point of the alloy, mixed thoroughly and poured into a cold mold, forming a thin bar approximately ¼ in. thick. Saw cuts shall then be made entirely across this bar not more than 1 in. apart and evenly distributed throughout its length.

If it is impracticable to remelt the sample as above, saw cuts shall be made entirely across each piece at several points not more than 1 in. apart and evenly distributed throughout their length. No lubricants shall be used for sawing.

(*c*) Sawings thoroughly mixed shall constitute the sample for chemical analysis.

Methods of Chemical Analysis. 7. The chemical analysis shall be made in accordance with the Tentative Methods for Chemical Analysis of Alloys of Lead, Tin, Antimony and Copper (Serial Designation: B 18–20 T) of the American Society for Testing Materials.[1]

III. MARKING.

Marking. 8. The name of the manufacturer may be cast, at the option of the purchaser, on each bar or ingot. The numerical designation of the grade supplied shall be stamped or cast on each bar or ingot for identification.

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[1] See p. 589.

IV. INSPECTION AND REJECTION.

Inspection. 9. (*a*) Inspection may be made at the manufacturer's works where the solder metal is made, or at the point at which it is received, at the option of the purchaser.

(*b*) If the purchaser elects to have inspection made at the manufacturer's works, the inspector representing the purchaser shall have free entry, at all times while work on the contract of the purchaser is being performed, to all parts of manufacturer's works which concern the manufacture of the material ordered. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications. All tests and inspection shall be so conducted as not to interfere unnecessarily with the operation of the works.

Rejection. 10. If the sample selected to represent a lot fails to conform to the requirements specified in Sections 3 and 4, all solder metal in such lot will be rejected.

V. CLAIMS.

Claims. 11. Claims, to be considered, shall be made in writing within thirty days of receipt of material at the purchaser's plant, and the results of the purchaser's tests shall be given. The shipper shall within one week of receipt of such claim, either agree to satisfy the claim or send a representative to the purchaser's plant to resample the shipment, as specified in Section 6. Samples so taken shall be sealed and submitted to a mutually agreeable umpire, whose determination shall be final.

Settlement of Claims. 12. The expense of umpire analysis shall be paid by the loser, or divided in proportion to the concession made in case of a compromise. In case of rejection being established, the damages shall be limited to the payment of freight both ways by the manufacturer for the substitution of an equivalent weight of solder metal meeting these specifications.

APPENDIX.

It is recommended that the grade of solder metal be selected which contains the least amount of tin required to give suitable flowing and adhesive qualities for the work in hand.

A table is appended showing the melting points of the different grades of solder metal and of tin and lead for comparison. It is to be noted that the alloys are completely solid below the lower point given, designated "melting point", and completely liquid only above the higher point given, designated "complete liquation point." In the range of temperature between these two points the alloys are partly solid and partly liquid. In Grade No. 1 the amount of solid portion is so small in the range given that it is practically unnoticeable. In Grade No. 4 the proportion of solid and fluid metal in the range given makes this alloy suitable for use as wiping solder.

The data in this appendix do not constitute a part of these specifications. They are given merely to indicate to the purchaser the physical properties of the various alloys specified which can be expected of carefully manufactured alloys of the formulas indicated, and to constitute a guide to the purchaser in selecting the grade best suited for meeting the service condition for which the solder metal is to be used.

TABLE SHOWING MELTING POINTS OF SOLDER METAL.

Grade.	Formula.			Melting Point.		Complete Liquation Point.	
	Tin, per cent.	Lead, per cent.	Antimony, per cent.	Deg. Cent.	Deg. Fahr.	Deg. Cent.	Deg. Fahr.
Tin	100.00	......	......	232	449.6	232	449.6
0 A	63.00	37.00	0.12	181	357.8	181	357.8
1 A	50.00	50.00	0.12	181	357.8	213	415.4
1 B	49.25	50.00	0.75	185	365.0	208	397.4
2 A	45.00	55.00	0.12	181	357.8	225	437.0
2 B	43.50	55.00	1.50	188	370.4	220	428.0
3 A	40.00	60.00	0.12	181	357.8	237	458.6
3 B	38.00	60.00	2.00	188	370.4	228	442.4
4 A	37.50	62.50	0.12	181	357.8	241	467.6
4 B	35.50	62.50	2.00	188	370.4	231	411.8
5 A	33.00	67.00	0.12	181	357.8	252	485.6
5 B	31.00	67.00	2.00	188	370.4	235	455.0
Lead	......	100.00	......	327	620.6	327	620.6

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TENTATIVE SPECIFICATIONS
FOR
TINNED SOFT OR ANNEALED COPPER WIRE FOR RUBBER INSULATION.[1]

Serial Designation: B 33 – 19 T.

These specifications are issued under the fixed designation B 33; the final number indicates the year of original issue or in the case of revision, the year of last revision.

ISSUED, 1919.

Product Covered. 1. These specifications cover tinned soft or annealed copper wire suitable for use in making rubber insulated wires and cables.

I. MANUFACTURE.

Manufacture. 2. The tinned wire shall be made by coating soft or annealed copper wire with pure tin. The copper used shall be of such quality and purity that after tinning it shall have the properties and characteristics hereinafter required.

II. CHEMICAL PROPERTIES AND TESTS.

Continuity of Coating. 3. The continuity of the tin coating shall be determined by the Sodium Polysulfide test, which shall be applied as specified in Sections 4 to 10.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1921, to Mr. J. A. Capp, Chairman of Committee B-1 on Copper Wire, General Electric Co., Schenectady, N. Y.

(*A*) *Treatment of Samples.*

4. Samples shall have a length of about 6 in., and they shall be tagged or marked to correspond with the coil or reel from which they were cut. **Length of Samples.**

5. The samples shall be thoroughly cleaned by immersion in benzine, redistilled petroleum ether, ether, or carbon tetrachloride for at least 3 minutes, then removed and wiped dry with a clean, soft cloth. The samples thus cleaned shall be kept in a clean, dry cloth until tested. The part of the sample to be immersed in the test solution shall not be handled. Care shall be taken to avoid abrasion by the cut ends. **Treatment of Samples.**

(*B*) *Method of Testing.*

6. (*a*) A length of at least $4\frac{1}{2}$ in. of the cleaned samples shall be immersed, in accordance with the following cycles, in test solutions maintained at a temperature between 15.5 and 21° C. (60 and 70° F.): **Immersion of Samples.**

First: Immerse for 1 minute in HCl solution as hereinafter defined. Wash and wipe dry.

Second: Immerse for 30 seconds in sodium-polysulfide solution as hereinafter defined. Wash and wipe dry.

Third: Immerse for 1 minute in HCl solution. Wash and wipe dry.

Fourth: Immerse for 30 seconds in sodium-polysulfide solution. Wash and wipe dry.

(*b*) After each immersion the samples shall be immediately and thoroughly washed in clean water and wiped dry with a clean, soft cloth.

7. After the above-described operations, the samples shall be examined in order to ascertain if copper exposed through openings in the tin coating has been blackened by the action of the sodium polysulfide. The sample shall be considered to have failed if by such blackening exposed copper is revealed. No attention shall be paid to blackening within $\frac{1}{2}$ in. of the cut end. **Examination of Samples.**

8. A mechanical test for adhesion of tinning may be made by bending the wire around a rod having a diameter equal to four times the diameter of the wire, and dipping the bent portion of **Mechanical Test for Adhesion.**

the wire in the sodium-polysulfide solution only, for 30 seconds. Any cracking or parting of the coating will be shown by blackening of the copper. Such cracking or parting of the coating will be a cause for rejection.

(C) *Testing Solution.*

9. (*a*) The hydrochloric-acid solution, specific gravity 1.008, shall be made in the following manner: Commercial HCl, sp. gr. 1.12, shall be diluted with distilled water to a specific gravity of 1.088 measured at 15°.5 C. (60° F.).

(*b*) A portion of HCl solution having a volume of 180 cc. shall be considered exhausted when there have been immersed in it for two cycles the number of test samples of any size as indicated in the following table:

Diameter, in.	Maximum Number to be Tested for Two Cycles in 180 cc. of Acid Solution.
0.460 to 0.141	2
0.140 to 0.086	4
0.085 to 0.051	6
0.050 to 0.039	10
0.038 to 0.031	12
0.030 to 0.003	14

For wire whose diameter is between listed sizes, the number of samples shall be the same as for the next larger size indicated.

Sodium-Polysulfide Solution.

10. The sodium-polysulfide test solution, sp. gr. 1.142, shall be made in the following manner: A concentrated solution shall be made by dissolving sodium-sulfide crystals in distilled water until the solution is saturated at about 21° C. (70° F.), adding about 250 g. of flowers of sulfur per liter, and allowing to stand for at least 24 hours.

The test solution shall be made by diluting a portion of the concentrated solution with distilled water to a specific gravity of 1.142 at 15°.5 C. (60° F.). The sodium-polysulfide test solution should have sufficient strength to blacken thoroughly a piece of clean untinned copper wire in 5 seconds. A portion of test solution used for testing samples will not be considered exhausted until it fails to blacken a piece of clean copper as above described.

III. PHYSICAL PROPERTIES AND TESTS.

(*A*) *Mechanical.*

Tensile Properties.

11. (*a*) The tensile strength and elongation of the tinned copper wire shall conform to the values in Table I.

TABLE I.—TENSILE PROPERTIES.

Diameter, in.	Tensile Strength, max., lb. per sq. in.	Elongation in 10 in., min., per cent.
0.460 to 0.290	36 000	30
0.289 to 0.103	37 000	25
0.102 to 0.021	38 500	20
0.020 to 0.012	39 000	15
0.011 to 0.003	40 000	10

(*b*) For wire whose nominal diameter is between listed sizes, the requirements shall be those of the next larger size indicated in Table I.

(*B*) *Electrical.*

Resistivity.

12. The resistivity of the wire expressed in pounds per mile ohm at 20° C. (68° F.) shall not exceed the values in Table II.

TABLE II.—RESISTIVITY.

Diameter, in.	Resistivity, lb. per mile ohm at 20° C.
0.460 to 0.290	896.15
0.289 to 0.103	900.77
0.102 to 0.021	910.15
0.020 to 0.012	929.52
0.011 to 0.003	938.20

IV. PERMISSIBLE VARIATIONS.

Permissible Variations.

13. (*a*) The size shall be expressed as the diameter of the wire in decimal fractions of an inch.

(*b*) The permissible variation from nominal diameter shall be:

For wire 0.010 in. or over in diameter, 1 per cent under and 3 per cent over;

For wire under 0.010 in. in diameter, 0.0001 in. under and 0.0003 in. over.

(*c*) For coiled wire, each coil shall be gaged in three places; one near each end, and one approximately at the middle. For spools, approximately 12 ft. shall be reeled off and the wire shall be gaged in six places between the second and twelfth foot from the end.

(*d*) The coil or spool will be rejected if the average gage is not within the limits specified in Paragraph (*b*).

V. WORKMANSHIP AND FINISH.

Workmanship. 14. The tin coating shall consist of a smooth continuous layer, firmly adherent to the surface of the copper.

VI. INSPECTION AND REJECTION.

Inspection. 15. The manufacturer shall afford the inspector representing the purchaser, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications.

Rejection. 16. Wire which shows exposed copper by blackening after testing in the sodium-polysulfide solution, as described, or which fails to conform with the other requirements of these specifications, shall be rejected.

EXPLANATORY NOTE.

The coating of tin on copper wire is for the purpose of protecting the copper against the action of the rubber insulation. It is, therefore, necessary that the coating be continuous. The test in the sodium-polysulfide is for the purpose of determining whether or not the wire carries a continuous envelope of pure tin.

The thickness of the tin coating is necessarily varied. Under the same conditions of tinning the coating on all sizes of wire, excepting on fine wire, is approximately the same. The coating on fine wire is generally relatively heavier than that on coarse wire. It is not, therefore, correct to apply a larger number of cycles in the test on coarse wire than is applied to fine wire. It is probable that one cycle of the dip test would be sufficient to discover defects in tinned wire, but in order to make certain that no partially covered spots may escape attention, two cycles have been provided for. It has been found that the tin coating on copper wire consists of two parts, an envelope of pure tin on the outside, with an intermediate layer of copper-tin alloy. This tin alloy, as well as the amount of tin present, has an effect on the resistivity of the wire. Since the relative amount of tin coating and alloy is greater on the small wire than it is on the coarser wire, the resistivity of the wire increases as the size decreases. This also accounts for the decrease in elongation due to tinning soft wire.

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TENTATIVE SPECIFICATIONS
FOR
SHEET HIGH BRASS.[1]

Serial Designation: B 36 – 20 T.

These specifications are issued under the fixed designation B 36; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1920.

Material Covered. 1. These specifications cover commercial sheet brass commonly used for drawing, forming, stamping and bending. It should be understood that they are general. Since high brass is used for many purposes where the requirements of the operations used are too particular to be specified by any of the ordinary physical tests, it is frequently advisable to submit samples or drawings to the manufacturer and secure an adjustment of anneal or temper to suit the actual operations to which the material is to be submitted.

I. MANUFACTURE.

Composition. 2. (*a*) Sheet high brass shall be made from Lake or Electrolytic Copper conforming to the requirements of the Standard Specifications for Lake Copper Wire Bars, Cakes, Slabs, Billets, Ingots and Ingot Bars (Serial Designation: B 4) or the Standard

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1921, to Mr. William Campbell, Chairman of Committee B-2 on Non-Ferrous Metals and Alloys, Columbia University, New York City.

Specifications for Electrolytic Copper Wire Bars, Cakes, Slabs, Billets, Ingots, and Ingot Bars (Serial Designation: B 5) of the American Society for Testing Materials,[1] and zinc of Grade 3 of the Standard Specifications for Spelter (Serial Designation: B 6) of the American Society for Testing Materials.[1] Clean new scrap resulting from manufacturing operations upon material complying with these specifications or composed of material of equal purity may be employed.

(*b*) The brass shall be manufactured by the cold-rolling and annealing process and may be furnished in either the cold-rolled or annealed condition, as required.

II. CHEMICAL PROPERTIES.

Chemical Composition. 3. The brass shall conform to the following requirements as to chemical composition:

Copper	64.5 to 67.5		per cent
Lead	not over	0.30	"
Iron	" "	0.05	"
Zinc	remainder		
Other impurities	not over	0.10	"

Chemical Analyses. 4. Analysis shall be made on each lot of 10,000 lb. or less. Drillings, millings or clippings shall be taken from at least 10 separate coils or pieces. Drillings or millings shall be taken on material thicker than 0.040 in. Clippings may be taken with shears from metal thinner than 0.040 in. Equal quantities shall be taken from each piece and thoroughly mixed together. Samples so prepared shall be divided into three equal parts, each of which shall be placed in a sealed package, one for each party and one for an umpire if necessary.

Check Analyses. 5 (*a*) Analyses of separate pieces may be made by the purchaser. The copper, lead, and iron determined shall be within the following limits:

Copper	64.00 to 68.00		per cent
Lead	not over	0.35	"
Iron	" "	0.07	"

(*b*) In case of dissatisfaction the metal shall be resampled in the presence of representatives of both parties. The thoroughly mixed sample shall be divided into three equal parts, each one of which shall be placed in a sealed package, one for each party and one for an umpire if necessary.

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[1] 1918 Book of A.S.T.M. Standards.

III. TEMPER AND ANNEAL.

Temper.

6. The temper of sheet brass shall be designated as follows:

	Reduction, B. & S. Gage Nos.
Quarter Hard	1
Half Hard	2
Hard	4
Extra Hard	6
Spring	8

Anneal.

7. Annealed sheet brass shall be designated as follows:

Light Anneal.
Drawing Anneal.
Soft Drawing Anneal.

IV. PHYSICAL PROPERTIES AND TESTS.

(*A*). *Hard Brass.*

Hardness Tests, Hard Brass.

8. The average Brinell hardness of 10 samples of cold-rolled brass 0.080 in. or over in thickness shall be within the following limits:

Quarter Hard	75 – 95
Half Hard	95 – 115
Hard	130 – 150
Extra Hard	150 – 170
Spring	160 – 180

Tensile Tests, Hard Brass.

9. The average of tension tests of two samples of cold-rolled brass thinner than 0.080 in. shall conform to the following minimum requirements:

	Tensile Strength, lb. per sq. in.	Elongation in 2 in., per cent.
Quarter Hard	45 000	27.5
Half Hard	52 500	15.0
Hard	67 500	5.0
Extra Hard	80 000	2.0
Spring	87 500	1.0

(*B*) *Soft Brass.*

Hardness Tests, Soft Brass.

10. The average Brinell hardness of ten samples of annealed brass 0.080 in. or over in thickness shall be as follows:

Light Anneal	65 - 75
Drawing Anneal	55 - 65
Soft Drawing Anneal	47 - 55

Tension Tests, Soft Brass.

11. The average of tension tests of two samples of annealed brass thinner than 0.080 in. shall conform to the following minimum requirements:

	TENSILE STRENGTH, LB. PER SQ. IN.	ELONGATION IN 2 IN., PER CENT.
Light Anneal	45 000	32.0
Drawing Anneal	42 000	38.0
Soft Drawing Anneal	40 000	42.0

V. PERMISSIBLE VARIATION IN DIMENSIONS.

Width.

12. The width of sheared metal shall not vary more than 0.010 in.

Thickness.

13. The standard method of specifying thickness shall be in terms of Brown & Sharpe Gage. When the thickness is specified in either common or decimal fractions of an inch, the tolerances shall be those of the corresponding group of Brown & Sharpe sizes in the following table:

TABLE I.—PERMISSIBLE VARIATION IN THICKNESS, IN.

Thickness, B. & S. Gage No.	Thickness, in.	Width, in.			
		Up to 5, incl.	Over 5 to 8, incl.	Over 8 to 11, incl.	Over 11 to 14, incl.
0000 to 0, incl	0.4600 to 0.3248	±0.0044	±0.0048	±0.0051	±0.0055
Below 0 " 4, "	0.3248 " 0.2043	±0.0039	±0.0043	±0.0046	±0.0050
" 4 " 8, "	0.2043 " 0.1284	±0.0034	±0.0038	±0.0041	±0.0045
" 8 " 14, "	0.1284 " 0.0640	±0.0029	±0.0033	±0.0036	±0.0040
" 14 " 18, "	0.0640 " 0.0403	±0.0025	±0.0029	±0.0033	±0.0037
" 18 " 24, "	0.0403 " 0.0201	±0.0020	±0.0024	±0.0028	±0.0032
" 24 " 28, "	0.0201 " 0.0126	±0.0016	±0.0020	±0.0024	±0.0028
" 28 " 32, "	0.0126 " 0.0079	±0.0013	±0.0017	±0.0020	±0.0024
" 32 " 35, "	0.0079 " 0.0056	±0.0010	±0.0014	±0.0017	±0.0022
" 35 " 38, "	0.0056 " 0.0039	±0.0008	±0.0012	±0.0015	±0.0019

Length.

14. Metal may be furnished in coils or flat strips as required. Coils shall consist of not more than three lengths, no one of which shall be less than 10 ft. long. When furnished in flat strips a variation of $\frac{1}{16}$ in. over the specified length will be permitted on full-length sheets.

Acceptable Short Lengths.

15. (*a*) When ordered in lengths over 10 to 12 ft.,

40 per cent may be 10 ft. and over.
30 " " " 8 to 10 ft.
20 " " " 6 to 8 ft.
10 " " " 4 to 6 ft.

Not more than 40 per cent of any one shipment may be less than the length ordered.

(*b*) When ordered in 10 ft. lengths,

40 per cent may be 8 ft. and over.
30 " " " 6 to 8 ft.
20 " " " 4 to 6 ft.
10 " " " 2 to 4 ft.

Not more than 40 per cent of any one shipment may be less than 10 ft.

(*c*) When ordered in 8 ft. lengths,

30 per cent may be 6 ft. and over.
20 " " " 4 to 6 ft.
10 " " " 2 to 4 ft.

Not more than 30 per cent of any one shipment may be less than 8 ft.

(*d*) When ordered in 6 ft. lengths,

20 per cent may be 4 ft. and over.
10 " " " 2 to 4 ft.

Not more than 20 per cent of any one shipment may be less than 6 ft.

(*e*) When special lengths are required, they shall be specified in the order.

VI. WORKMANSHIP AND FINISH.

Finish.

16. The brass shall be free from injurious external and internal defects of a nature which will interfere with the purpose for which it is intended. It shall be well cleaned and free from dirt.

VII. INSPECTION AND REJECTION.

Inspection. 17. The manufacturer shall afford the inspector representing the purchaser, free of cost, all reasonable facilities to satisfy him that the material is being furnished in accordance with these specifications.

Rejection. 18. Material which fails to conform to these specifications will be rejected and the manufacturer shall be notified.

EXPLANATORY NOTE.

Section 2.—In the making of brass the best results are obtained if a minimum of one-third of previously alloyed material is used. It is also frequently desirable to employ previously alloyed material composed of copper and zinc in proportions other than provided for in these specifications, sufficient copper and zinc being added as may be required to properly correct the composition.

AMERICAN SOCIETY FOR TESTING MATERIALS
PHILADELPHIA, PA., U. S. A.
AFFILIATED WITH THE
INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE SPECIFICATIONS FOR ALUMINUM FOR USE IN THE MANUFACTURE OF IRON AND STEEL.[1]

Serial Designation: B 37 – 20 T.

These specifications are issued under the fixed designation B 37; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1920.

Material Covered.

1. These specifications cover two grades of Virgin and four grades of Secondary Aluminum, as follows:

(*a*) *Virgin Aluminum.*

(1) *98.0 Grade*, containing not less than 98 per cent aluminum. This grade is identical with the 98.0 Grade specified in the Tentative Specifications for Aluminum Ingots for Remelting and for Rolling (Serial Designation: B 24 – 20 T) of the American Society for Testing Materials.[2]

(2) *94.0 Grade*, containing not less than 94 per cent aluminum. The remainder may be chiefly iron and silicon.

(*b*) *Secondary Aluminum.*

(1) *98.0 Grade*, containing not less than 98 per cent aluminum. This grade is generally made from sheet clippings. The remainder may be chiefly copper, iron and silicon.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1921, to Mr. William Campbell, Chairman of Committee B-2 on Non Ferrous Metals and Alloys, Columbia University, New York City.

[2] See p. 543.

(2) *94.0 Grade*, containing not less than 98 per cent aluminum. A maximum of 0.5 per cent of zinc will be allowed in this grade. The remainder may be chiefly copper.

(3) *90.0-A Grade*, containing not less than 90 per cent aluminum. A maximum of 0.5 per cent of zinc will be allowed in this grade. The remainder may be chiefly copper.

(4) *90.0-B Grade*, containing not less than 90 per cent aluminum. A maximum of 4 per cent of zinc will be allowed in this grade. The remainder may be chiefly copper.

I. MANUFACTURE.

Manufacture. 2. The manufacturer shall use care to have each lot of metal as uniform as possible.

3. The aluminum may be in the form of ingots, rods or shot.

Ingots should be of convenient size for use. Ingots with a minimum of five notches, weighing approximately 3 lb. will meet the requirements of these specifications.

Rods may be either rolled or cast and $\frac{3}{8}$ to $\frac{1}{2}$ in. in diameter.

Shot should be of convenient size. That produced by running the molten metal through $\frac{1}{8}$-in. diameter holes is satisfactory.

II. SAMPLING.

Sampling. 4. If the aluminum is shipped in carload lots, random samples shall be taken but not less than five ingots for each car. If the shipment is in less than carload lots, one ingot shall be taken for each 10,000 lb. (4536 kg.) or fractional part thereof.

Drilling. 5. The ingots selected shall be drilled completely through, or half through from top and bottom. The drillings shall be fine, thin chips. They shall be thoroughly mixed, and the sample for analysis shall not be less than 60 g.

Rods shall be sampled in a similar manner, except that the drilling shall be radial.

An equivalent amount of shot shall be taken as a sample and reduced by quartering to a sample of convenient size.

III. ANALYSES.

Analyses. 6. Analyses shall be made in accordance with standard methods to be furnished by the committee.

IV. MARKING.

Marking. 7. The maker's brand and the grade of aluminum shall be cast or rolled on each ingot or rod and marked plainly on each container of shot metal. When marking the grade by casting or rolling is not practicable, the grade shall be indicated by spotting each large ingot or one ingot or rod from each bundle with a designating color of paint, red indicating the 98.0 Virgin grade, yellow the 94.0 Virgin grade, red and white the Secondary 98.0 Grade, red and yellow the Secondary 94.0 Grade, red and blue the Secondary 90.0-A Grade, and red and black the Secondary 90.0-B Grade.

V. CLAIMS.

Claims. 8. Claims, to be considered, shall be made in writing within ten days of receipt of material at the purchaser's plant, and the results of the purchaser's tests shall be given. The vender shall within ten days of such claim, either agree to satisfy the claim or send a representative to the purchaser's plant to resample the shipment as specified in Section 3. Samples so taken shall be sealed and submitted to a mutually agreeable umpire, whose determination shall be final.

10. The expense of the umpire analysis shall be paid by the loser, or divided in proportion to the concession made, in case of compromise. In case rejection is established, the damage shall be limited to the payment of freight both ways by the vender for the substitution of an equivalent weight of metal meeting specifications.

AMERICAN SOCIETY FOR TESTING MATERIALS
PHILADELPHIA, PA., U. S. A.
AFFILIATED WITH THE
INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE METHODS FOR CHEMICAL ANALYSIS OF ALLOYS OF LEAD, TIN, ANTIMONY AND COPPER.[1]

Serial Designation: B 18 – 20 T.

These methods are issued under the fixed designation B 18; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917; REVISED, 1920.

Two sets of methods are here given. The first method is somewhat slow but is recommended as giving the more accurate results where the analysis of these alloys is of comparatively infrequent occurrence. The second method is rapid and is suitable for control work, giving good results after the analyst has become familiar with it.

I.—GENERAL METHOD.[2]

A. DETERMINATION OF LEAD, COPPER, ANTIMONY AND TIN.

DETERMINATION OF LEAD.

SOLUTIONS REQUIRED.

Mixed Acid.—Dissolve 20 g. of KCl in 500 cc. of water, add 400 cc. of HCl (sp. gr. 1.20), mix and add 100 cc. of HNO_3 (sp. gr. 1.42).

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[1] Criticisms of these Tentative Methods are solicited and should be directed, preferably before January 1, 1921, to Mr. William Campbell, Chairman of Committee B-2 on Non-Ferrous Metals and Alloys, Columbia University, New York City.

[2] G. W. Thompson's method. See *Journal*, Soc. Chem. Ind. Vol. 15, p. 179.

Alcohol-Hydrochloric Acid Mixture.—Mix 400 cc. of 95-per-cent ethyl alcohol and 100 cc. of HCl (sp. gr. 1.20).

Acid Ammonium Acetate.—To 500 cc. of NH_4OH (sp. gr. 0.90), add 500 cc. of water and then acetic acid (80-per-cent), until slightly acid to litmus.

METHOD.

Dissolve 1 g. of the finely divided alloy by boiling in 70 to 100 cc. of "mixed acid" solution in a covered beaker. Add more "mixed acid" if a complete solution of the alloy is difficult to obtain, and continue boiling until evaporated to about 50 cc. Add 5 cc. of HCl (sp. gr. 1.20), cool in ice water until the bulk of $PbCl_2$ has crystallized out, then add slowly, with constant stirring, 50 cc. of alcohol (95-per-cent), continue stirring for a few minutes and cool in ice water for 10 minutes. Add 50 cc. more alcohol from a pipette, allow to stand in ice water for 20 minutes and filter through 9-cm. paper into an 800-cc. beaker. Wash by decantation three times with alcohol-hydrochloric acid mixture and finally wash the paper twice with the same mixture. Wash the $PbCl_2$ from the paper back into the beaker; wash paper several times with hot water, catching washings in beaker with the bulk of the chloride. Finally wash paper with hot acid ammonium acetate solution. Heat until all $PbCl_2$ is dissolved. Add 15 cc. of saturated solution of $K_2Cr_2O_7$; heat until precipitate is of good orange color; filter on weighed Gooch crucible; wash with water, alcohol and ether; dry at 110° C. and weigh. Calculate percentage of lead by the empirical factor 63.75.

NOTES

1. With proper manipulation, the $PbCl_2$ precipitate should contain consistently all but 0.003 g. of lead.

2. During the heating of the acid ammonium acetate to dissolve the $PbCl_2$, the solution should remain perfectly clear, any turbidity indicating the presence of tin or antimony, as even 1 mg. of tin or antimony will cause a slight but distinct turbidity.

DETERMINATION OF COPPER AND ANTIMONY.

SOLUTIONS REQUIRED.

Potassium Hydroxide.—Dissolve 100 g. of KOH in 500 cc. of water.

Potassium Cyanide.—Dissolve 3.5 g. of KCN in 1800 cc. of water and standardize against copper of known purity.

Sodium Thiosulfate.—Dissolve 24.8 g. of $Na_2S_2O_3.5H_2O$ in 1000 cc. of water, and allow to stand for 24 hours. Standardize against Antimony Metal c. p., using same quantity of reagents and same procedure as under (*c*) Determination of Antimony.

METHOD.

See "Determination of Lead."

Evaporate the filtrate from $PbCl_2$ filtration by boiling in the loosely covered 800-cc. beaker, and finally take to dryness on a water bath. Add 10 cc. of KOH solution and after a few minutes add 20 cc. of 3-per-cent H_2O_2. Add more KOH, if solution is acid, until an alkaline reaction is shown by litmus paper. Heat on the water bath for 20 minutes, add 10 g. of ammonium oxalate, 10 g. of oxalic acid, and 200 cc. of water and heat to boiling. Pass in H_2S for 45 minutes with solution near boiling; filter at once; and wash precipitate with hot water, catching washings with filtrate.

Wash the precipitate of copper and antimony sulfides from the filter paper back into the beaker with the least amount of water possible; treat with 10 cc. of KOH solution; heat on water bath until the undissolved matter is distinctly black, filter through same paper into a 300-cc. Erlenmeyer flask. Wash the precipitate with hot water.

(*a*) *Determination of Copper by Potassium Cyanide Titration.*

Dry and ignite the precipitate with paper in a small casserole, dissolve in nitric acid (sp. gr. 1.42), boil to expel nitrous fumes, neutralize with Na_2CO_3, add a few drops of NH_4OH and titrate with standard KCN solution.

(*b*) *Determination of Copper by Electrolytic Method.*

See "Determination of Copper by Potassium Cyanide Titration."

Dry and ignite the sulfide precipitate in a small casserole, dissolve in 10 cc. of HNO_3 (sp. gr. 1.42), boil until oxides of nitrogen are expelled and add 50 cc. of distilled water. Transfer to a tall 200-cc. beaker, wash out casserole, add 5 cc. of H_2SO_4 (sp. gr. 1.84) and determine copper by electrolysis. See the determination of copper by the electrolytic method in the Standard Methods for Chemical Analysis of Manganese Bronze (Serial Designation: B 27) of the American Society for Testing Materials.[1]

NOTES.

1. On filter after heating with KOH solution, the copper remains as sulfide with a small amount of lead sulfide which failed to be precipitated as chloride. If it is desired to determine this lead, it can be done by separation rom the copper by ordinary methods.

2. If the amount of antimony and copper is small (less than 10 mg.) the lead which failed to be precipitated as chloride may also fail to come down as sulfide on passing H_2S through the oxalic solution. It will remain in the filtrate from the sulfides and be deposited electrolytically with the tin on the cathode. This can be prevented by adding an oxalic acid solution of a pure antimony salt containing about 100 mg. of antimony just before passing H_2S. In this case antimony must be determined on a separate portion.

3. If the amount of copper present is from 8 to 10 mg. or more, it should be determined by the electrolytic method. In this case, the small amount of lead precipitated as sulfide with the copper is deposited on the anode as PbO_2 and may be weighed, calculated to lead by factor 86.43 and added to that obtained under "Determinations of Lead".

(*c*) *Determination of Antimony.*

See "Determination of Copper by Potassium Cyanide Titration."

Add 50 cc. of HCl (sp. gr. 1.20) to the KOH solution of antimony sulfide, and boil down to small volume until all arsenic has been expelled as arsenious chloride.

Add 25 cc. of HCl (sp. gr. 1.20) and 1 g. of $KClO_3$ and boil until colorless. Filter into a 300-cc. Erlenmeyer flask, through glass wool if sulfur has separated, wash out original flask with HCl (sp. gr. 1.20), cool, add 1 g. of KI, 1 cc. of CS_2, and titrate with standard thiosulfate solution.

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[1] A.S.T.M. Standards Adopted in 1919.

DETERMINATION OF TIN.

Apparatus for Electrolysis.

Electrodes.—Cylindrical cathodes of platinum wire gauze—2 by $1\frac{3}{8}$ in. diameter.

Platinum wire spiral anodes.

Method.

See "Determination of Copper and Antimony."

Concentrate the filtrate and washings from the precipitated sulfides, if necessary, to a volume of 200 cc. and add 5 g. more of oxalic acid in case the amount of tin is over 0.5 g. Electrolyze until the solution reacts alkaline, using a current of about 0.5 amperes. Remove the cylinder; wash twice with distilled water and once with 95-per-cent ethyl alcohol; dry at 110° C. and weigh.

Note.

If the electrolysis is carried out over night it will usually be found by morning that the solution has become alkaline and it may be taken for granted that the tin has all been precipitated on the cathode. The best results are obtained by regulating the current, or the time, so as to render the solution alkaline only a very short time before the cathode is to be removed. The cathode should be placed close to the bottom of the beaker to insure proper agitation of the electrolyte.

B. DETERMINATION OF ARSENIC.

Solutions Required.

Ferric Chloride.—Solution of specific gravity 1.43.

Ammonium Carbonate.—Dissolve 75 g. in 500 cc. of water.

Method.

Weigh 1 g. of sample into a 250-cc. distillation flask and add 10 cc. of $FeCl_3$ solution, 60 cc. of HCl (sp. gr. 1.20) 20 cc. of water and 5 g. of KCl. Connect the flask with a condenser, heat slowly until solution is complete and boil down to as small a volume as possible, catching distillate in a tall 400-cc. beaker. Cool flask, add 50 cc. HCl (sp. gr. 1.20) and redistill as before, catching distillate in same beaker. Cool distillate and pass H_2S through for one hour, allow to settle and filter the arsenious sulfide on a Gooch crucible. Wash twice with HCl (1 : 4), four times with cold water, three times with alcohol and four times with CS_2. Dry at 110° C. for 10 minutes, and weigh after cooling. Dissolve the arsenious sulfide with $(NH_4)_2 CO_3$ solution, wash thoroughly with water, dry for 30 minutes at 110° C. and reweigh after cooling. The difference in weights multiplied by 0.60911 gives the percentage of arsenic.

II.—RAPID METHOD FOR CONTROL WORK.[1]

A. DETERMINATION OF LEAD AND COPPER.

SOLUTIONS REQUIRED.

"Lead Acid."—Mix 300 cc. of H_2SO_4 (sp. gr. 1.84) and 1800 cc. of distilled water. Dissolve 1 g. of lead acetate c. p. in 300 cc. of distilled water and add this to the hot solution, stirring meanwhile. Let stand at least 24 hours and siphon through a thick asbestos filter.

Dilute Alcohol for Washing.—Mix equal parts of denatured alcohol and distilled water.

METHOD.

(*a*) *Determination of Lead.*

In a covered 300-cc. beaker, dissolve 1 g. of the alloy in 20 cc. of H_2SO_4 (sp. gr. 1.84), heating the solution until the metal is completely decomposed and the $PbSO_4$ is white, and finally boil for $\frac{1}{2}$ hour. Allow to cool slightly, but not below 60° C., and add 100 cc. of water in which has been dissolved 5 g. of tartaric acid. Allow this solution to stand for two hours and filter on a weighed porcelain Gooch crucible, decanting as much of the solution as possible before bringing the precipitate on to the crucible. Wash with lead acid, retaining the filtrate and these washings for the copper determination. Remove the beaker containing these solutions and wash out the lead acid with dilute alcohol; set the Gooch crucible inside a porcelain crucible; dry and ignite for five minutes at the full heat of a Tirrill burner; cool and weigh as $PbSO_4$, which contains 68.29 per cent lead.

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[1] See "The Analysis of Alloys of Lead, Tin, Antimony and Copper," by D. J. Demorest, *Journal Ind. and Eng. Chem.*, Vol. V, p. 842; "Rapid Analysis of Alloys for Tin, Antimony, and Arsenic," by F. A. Stief, *Journal Ind. and Eng. Chem.*, Vol. VII, p. 211; and "Technical Analysis of Brass," 1917. Price and Meade, p. 182.

(*b*) *Determination of Copper.*

To the filtrate from the $PbSO_4$, which contains the copper and which has been transferred to an Erlenmeyer flask, add NH_4OH (sp. gr. 0.90) until the solution is slightly alkaline; then add 2 cc. of H_2SO_4 (sp. gr. 1.84); heat nearly to boiling; add 2 g. of Na_2SO_3 and when this is entirely dissolved add 1 g. of KCNS dissolved in 10 cc. of water. Shake well and allow the precipitated CuCNS to settle for one hour while the solution is kept hot. Filter on a close filter paper, wash with cold water and ignite paper and precipitate in a porcelain crucible. Proceed by one of the two following methods:

(1) Dissolve in HNO_3 (sp. gr. 1.42), add 5 cc. H_2SO_4 (sp. gr. 1.84); evaporate until fumes of H_2SO_4 are evolved. Dilute to about 100 cc. with distilled water. Add 1.5 cc. of HNO_3 (sp. gr. 1.42) and determine copper by electrolysis. See the "Determination of Copper by the Electrolytic Method," Standard Methods for Chemical Analysis of Manganese Bronze (Serial Designation: B 27) of the American Society for Testing Materials.[1]

(2) Dissolving the ignited precipitate in HNO_3 (sp. gr. 1.42), as in (1); boil to expel nitrous fumes, neutralize with Na_2CO_3 and determine volumetrically with cyanide as in *A* of "General Method."

NOTE.

If the amount of copper is very small it may escape detection by this method, in which case it should be determined as in *A* of "General Method."

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[1] A.S.T.M. Standards Adopted in 1919.

B. DETERMINATION OF ARSENIC, ANTIMONY AND TIN.

APPARATUS.

Arsenic Still.—A condenser is made from glass tubing in the form of a letter *S*, about 18 in. long and $\frac{1}{2}$ in. in inside diameter, tapering to about $\frac{1}{4}$ in. at the upper end and to about $\frac{1}{8}$ in. at the lower end. One curve is nearly filled with water, and is submerged in cold water in a 500-cc. beaker. The lower end dips into about 75 cc. of water in a 300-cc. beaker and the upper end is connected by a delivery tube with a 300-cc. Florence flask, closed with a rubber stopper which is fitted with a delivery tube and with a thermometer reaching to about 1 in. above the surface of the liquid in the flask.

SOLUTIONS REQUIRED.

Iodine.—Dissolve 10.7 g. of iodine in 50 cc. of distilled water which contains 20 g. of KI in solution and dilute to 1000 cc. with distilled water. Standardize against pure tin having exactly the same conditions for titration as are specified for the analysis of the alloy. Each cubic centimeter is equivalent to approximately 0.00500 g. of tin or 0.00315 g. of arsenic.

Potassium Permanganate.—Dissolve 2.7 g. of $KMnO_4$ in distilled water, filter through asbestos, and dilute to 1000 cc. with distilled water. Standardize against pure antimony having exactly the same conditions for titration as are specified for the analysis of the alloy. Each cubic centimeter is equivalent to approximately 0.00500 g. of antimony or 0.00465 g. of iron.

Ferrous Ammonium Sulfate.—Dissolve 12.4 g. of ferrous ammonium sulfate crystals in 950 cc. of distilled water and add 50 cc. of H_2SO_4 (sp. gr. 1.84).

Starch.—To 1000 cc. of boiling water, add a cold suspension of 6 g. of starch in 100 cc. of distilled water; cool, add a few drops of chloroform and mix thoroughly.

METHOD.

(*a*) *Determination of Arsenic.*

In a 300-cc. Florence flask, dissolve 0.5 g. of the alloy in exactly 8 cc. of H_2SO_4 (sp. gr. 1.84). The metal must be finely divided, preferably in the form of thin foil-like shavings, although sawings or very fine drillings may be used. Heat the solution to boiling; cool, add about 5 cc. of water and a bulk of about 0.5 cc. of clean granulated pumice stone and boil the covered solution very gently for about five minutes, or until the strong odor of SO_2 can no longer be detected. Finally, being careful to have 5 cc. of water present, cool the solution to about 18° C. and cautiously add 20 cc. of HCl (sp. gr. 1.20). Insert in the flask a rubber stopper fitted with a thermometer and delivery tube and connect the delivery tube with the "*S*" condenser. Heat the solution to gentle boiling for from 10 to 15 minutes, keeping the vapor temperature at 107° C. for at least 5 minutes. Wash out the condenser into a 300-cc. beaker and add an excess of about 2 g. of $NaHCO_3$. Bring the volume of the solution to about 200 cc.; warm to about 27° C. and titrate with standard iodine solution and starch to the appearance of a deep blue color.

NOTE.

A blank determination should be made on corresponding amounts of reagents treated as above, and the results should be corrected accordingly.

(*b*) *Determination of Antimony.*

Cool the solution which remains in the flask after the arsenic distillation; add about 130 cc. of cold, recently-boiled distilled water, to which has been added about 3 cc. of HCl (sp. gr. 1.20) and titrate with standard $KMnO_4$ solution to the appearance of a decided permanent pink color. From a burette add an excess of standard ferrous ammonium sulfate solution until the pink color is discharged and then titrate with standard $KMnO_4$ solution to the reappearance of a pink color.

(*c*) *Determination of Tin.*

If the sample does not contain 14 per cent (or 0.07 g.) of antimony, add enough dissolved $SbCl_3$ to the solution to bring the contents of antimony up to about 0.07 g. for the purpose of insuring perfect reduction of the tin and uniform conditions for the titration. Then add exactly 6 cc. of H_2SO_4 (sp. gr. 1.84) and 60 cc. of HCl (sp. gr. 1.20) and add about 6 in. of clean, soft No. 14 pure iron wire cut into 2-in. lengths and cleaned with dilute HCl just before using. Boil gently for ½ hour, add about 6 in. more wire and boil ½ hour longer. Remove from heat, close flask loosely with a rubber stopper and allow about two minutes for all air to be expelled by hydrogen and acid vapors. Close flask tightly and quickly place it in cold water, cooling the solution to about 20° C. Transfer the solution quickly to a 500-cc. beaker (leaving the iron wires in the flask) and rinse flask and contents with 150 cc. of cold, recently-boiled distilled water. Add rinsings to main solution in the beaker, bring final volume to about 300 to 350 cc. and titrate quickly with standard iodine solution and starch to the appearance of a strong blue color.

NOTES.

A blank determination should be made on corresponding amounts of reagents treated as above, and the results should be corrected accordingly.

If the copper contents of the alloy is as high as about 3 per cent or over, it prevents a good end point in the tin titration when the tin percentage is low. Under such conditions, just before titrating, add about 1 g. of KI crystals, stir until nearly dissolved and titrate immediately. If allowed to stand too long at this point, trouble may be encountered due to the precipitation of some of the other constituents.

Other forms of pure iron may be employed, but the wire as above specified has been found convenient.

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TENTATIVE SPECIFICATIONS AND TESTS FOR COMPRESSIVE STRENGTH OF PORTLAND-CEMENT MORTARS.[1]

Serial Designation: C 9 – 16 T.

These specifications and tests are issued under the fixed designation C 9; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1916.

SPECIFICATIONS.

Compressive Strength.

1. The average compressive strength in pounds per square inch of not less than three standard mortar test pieces (see Section 4) composed of one part cement and three parts standard sand, by weight, shall be equal to or higher than the following:

Age at Test, days.	Storage of Test Pieces.	Compressive Strength, lb. per sq. in.
7	1 day in moist air, 6 days in water	1200
28	1 day in moist air, 27 days in water	2000

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[1] Criticisms of these Tentative Specifications and Tests are solicited and should be directed, preferably before January 1, 1921, to Mr. P. H. Bates, Secretary of Committee C-1 on Cement, Bureau of Standards, Washington, D. C.

These specifications and tests, when adopted as standard, will be added to the present Standard Specifications and Tests for Portland Cement (Serial Designation: C 9–17), 1918 Book of A.S.T.M. Standards. As a result of a revision adopted by letter ballot September 1, 1920, to become effective January 1, 1921, these standard specifications will be published under the serial designation: C 9 – 21.

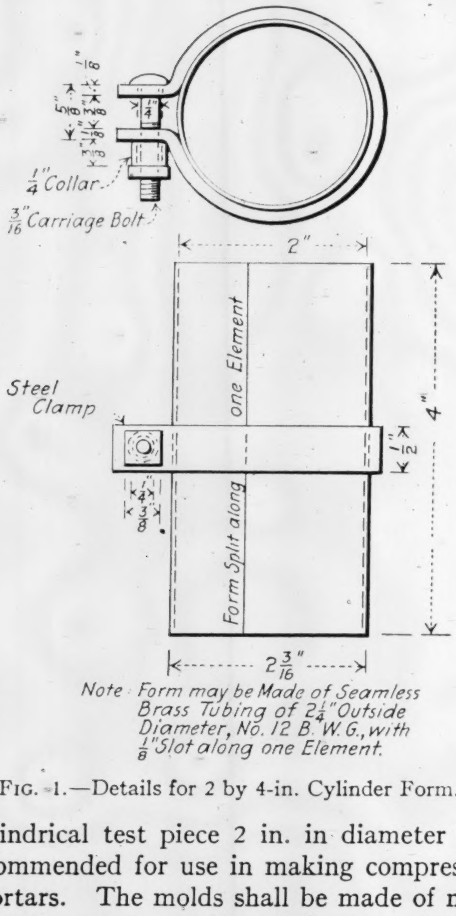
Strength at 28 days.

2. The average compressive strength of standard mortar at 28 days shall be higher than the strength at 7 days.

TESTS.

Mixing Standard Mortar.

3. The requirements governing the preparation of standard sand mortars for tension test pieces shall apply to compression test pieces.[1]



Note Form may be Made of Seamless Brass Tubing of $2\frac{1}{4}$" Outside Diameter, No. 12 B. W. G., with $\frac{1}{8}$" Slot along one Element.

FIG. 1.—Details for 2 by 4-in. Cylinder Form.

Form of Test Piece.

4. A cylindrical test piece 2 in. in diameter and 4 in. in length is recommended for use in making compression tests of standards mortars. The molds shall be made of non-corroding metal. A satisfactory form of mold is shown in Fig. 1. The ends of the mold shall be parallel. The tubing used in the

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[1] See Standard Specifications and Tests for Portland Cement (Serial Designation: C 9) 1918 Book of A.S.T.M. Standards.

molds shall be of sufficient thickness to prevent appreciable distortion. The molds shall be oiled before using. During the molding of the test piece, the mold shall rest on a clean, plane surface (preferably a piece of plate glass which is allowed to remain in place until the mold is removed).

Molding.

5. The mortar[1] shall be placed in the mold in layers about 1 in. in thickness, each layer being tamped by means of the steel tamper shown in Fig. 2. The weight of tamper shall be approximately ¾ lb. In finishing the test piece, the mortar shall be heaped above the mold and smoothed off with a trowel. As soon as the test pieces from one sample are molded, the top of each test piece shall be covered with a piece of glass which is brought to a firm bearing on the fresh mortar. The cover glasses shall remain in place until the molds are removed.

Storage.

6. The compression test pieces shall be stored in the same manner as the tension test pieces.

Testing.

7. Tests of standard-mortar cylinders shall be made in any testing machine which is adapted to meet the specified requirements. The test pieces shall be tested as soon as removed from the water. The ends of the test cylinders shall be smooth, plane surfaces. The metal bearing plates of the testing machine shall be placed in direct contact with the ends of the test piece. During the test a spherical bearing block shall be used on top of the cylinder. In order to secure a uniform distribution of the load over the test cylinder the spherical bearing block must be accurately centered. The diameter of the spherical bearing block should be only a little greater than that of the test piece. The test piece shall be loaded continuously to failure. The moving head of the testing machine shall travel at the rate of not less than 0.05 or more than 0.10 in. per minute.

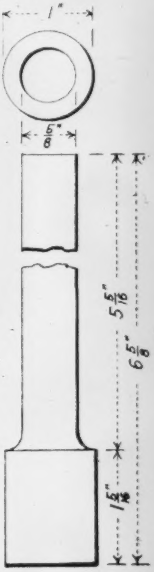

FIG. 2.—Details for Steel Tamper.

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[1] If sufficient mortar for six 2 by 4-in. cylinders is to be mixed in a single batch, approximately 3000 g. of material will be required. In this case the mixing shall be continued for 1½ minutes.

Calibration. 8. Testing machines should be frequently calibrated in order to determine their accuracy.

Faulty Cylinders. 9. Cylinders that are manifestly faulty, or which give strengths differing more than 15 per cent from the average value of all test pieces tested at the same period and made from the same sample, shall not be considered in determining the compressive strength.

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TENTATIVE SPECIFICATIONS
FOR
REQUIRED SAFE CRUSHING STRENGTHS OF SEWER PIPE TO CARRY LOADS FROM DITCH FILLING.[1]

Serial Designation: C 15 - 17 T.

These specifications are issued under the fixed designation C 15; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917.

The following table gives required safe crushing strengths per linear foot of pipe, to carry loads from ditch filling materials only when pipe is laid in accordance with the Recommended Practice for Laying Sewer Pipe (Serial Designation: C 12) of the American Society for Testing Materials,[2] for sand and for thoroughly wet clay ditch filling materials. In the preparation of this table a safety factor of $1\frac{1}{2}$ has been used, which has been found necessary to prevent cracking from the loads of ditch filling.[3]

Ordinary Pipe Laying is pipe laying in accordance with customary good practice in pipe sewer construction, whereby the under side of the pipe is well bedded on soil for 60 to 90 deg. of the circumference.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1921, to Mr. Rudolph Hering, Chairman of Committee C-4 on Clay and Cement Sewer Pipe, 40 Lloyd Road, Montclair, N. J.

[2] A.S.T.M. Standards Adopted in 1919.

[3] Prepared from the Standard Specifications for Drain Tile (C 4), 1918 Book of A.S.T.M. Standards.

First Class Pipe Laying is pipe laying in accordance with the best customary practice in pipe-sewer construction, whereby the entire under side of the pipe is very thoroughly bedded on soil and the entire pipe is surrounded by well-compacted soil, under the direction of an inspector constantly present on the work.

SAFE CRUSHING STRENGTHS OF SEWER PIPE TO CARRY LOADS FROM DITCH FILLING FOR ORDINARY SAND AND FOR THOROUGHLY WET CLAY DITCH FILLING MATERIALS.
(FOR ORDINARY PIPE-LAYING METHODS.)
STRENGTHS IN POUNDS PER LINEAR FOOT.

Height of Fill above Top of Pipe, ft.	Breadth of Ditch a Little Below Top of Pipe.									
	1 ft.		2 ft.		3 ft.		4 ft.		5 ft.	
	Ditch Filling Material.		Ditch Filling Material.		Ditch Filling Material.		Ditch Filling Material.		Ditch Filling Material.	
	Sand.	Clay.	Sand.	Clay.	Sand.	Clay.	Sand.	Clay.	Sand.	Clay.
2..........	265	280	615	635	970	990	1 330	1 350	1 690	1 710
4..........	400	450	1 055	1 125	1 745	1 825	2 455	2 535	2 165	2 250
6..........	470	545	1 370	1 500	2 370	2 525	3 405	3 575	4 460	4 640
8..........	505	605	1 600	1 790	2 875	3 115	4 215	4 495	5 595	5 890
10..........	525	640	1 765	2 015	3 275	3 610	4 900	5 295	6 590	7 020
12..........	535	660	1 880	2 185	3 600	4 030	5 485	6 000	7 460	8 035
14..........	540	675	1 965	2 320	3 855	4 380	5 975	6 620	8 225	8 950
16..........	545	680	2 025	2 425	4 065	4 675	6 395	7 165	8 890	9 775
18..........	545	685	2 070	2 505	4 230	4 920	6 750	7 630	9 480	10 520
20..........	545	690	2 100	2 565	4 365	5 130	7 050	8 060	9 995	11 190
22..........	545	690	2 125	2 610	4 470	5 305	7 305	8 425	10 445	11 795
24..........	545	690	2 140	2 645	4 560	5 455	7 525	8 750	10 840	12 340
26..........	545	690	2 150	2 675	4 630	5 575	7 705	9 035	11 185	12 830
28..........	545	690	2 160	2 695	4 685	5 680	7 860	9 280	11 490	13 270
30..........	545	690	2 165	2 715	4 725	5 765	7 990	9 500	11 755	13 670
Very great	545	690	2 180	2 770	4 910	6 230	8 725	11 075	13 635	17 305

When pipe are laid in a *Concrete or other Permanent Masonry Cradle*, strong enough to carry the entire load to the sub-base without breaking and large enough to prevent material settlement, the standard strengths for all dimensions of ditches and all filling materials shall be those specified for standard sewer pipe.

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TENTATIVE SPECIFICATIONS
FOR
MASONS' HYDRATED LIME.[1]

Serial Designation: C 6 – 19 T.

These specifications are issued under the fixed designation C 6; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917: REVISED, 1919.

Definition. 1. Masons' hydrated lime is a dry flocculent powder, resulting from the hydration of quicklime.

Uses. 2. Masons' hydrated lime may be used for making lime mortar, for scratch or brown coat of plaster, or for addition to Portland-cement mortar or concrete.

I. CHEMICAL PROPERTIES AND TESTS.

Sampling. 3. The sample shall be a fair average of the shipment. Three per cent of the packages shall be sampled. The sample shall be taken from the surface to the center of the package. A 2-lb. sample to be sent to the laboratory shall immediately be transferred to an air-tight container, in which the unused portion shall be stored until the shipment has been finally accepted or rejected by the purchaser.

Chemical Properties. 4. (*a*) The chemical composition of the hydrated lime shall be determined by standard methods of chemical analysis.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1921, to Mr. D. K. Boyd, Chairman of Committee C-7 on Lime, 701 Walnut St., Philadelphia, Pa.

These specifications, when adopted as standard, will supercede the present Standard Specifications for Hydrated Lime (Serial Designation: C 6-15), 1918 Book of A.S.T.M. Standards.

(*b*) *Impurities.*—The sum of the silica (SiO_2), ferric oxide (Fe_2O_3) and alumina (Al_2O_3) expressed on the sample as received shall not exceed 5 per cent.

(*c*) *Carbon Dioxide.*—Carbon dioxide in the sample as received shall not exceed 3 per cent.

(*d*) *Calcium and Magnesium Oxides.*—Calcium and magnesium oxides shall constitute not less than 90 per cent of the non-volatile portion.

II. PHYSICAL PROPERTIES AND TESTS.

Fineness.

5. (*a*) A 100-g. sample shall leave not more than 0.5 per cent of its weight on a standard 30-mesh sieve, and not more than 15 per cent of its weight on a standard 200-mesh sieve.

(*b*) The fineness test shall be made as specified in Section 12.

Constancy of Volume.

6. (*a*) A pat of mortar, covered with a skim coat of neat paste, shall be subjected to the action of steam. If the steam has no visible effect on the pat, the sample shall be reported as being "sound." If the pat disintegrates, the sample shall be reported "unsound" and the shipment rejected. If the sample cracks, pops, or shows other minor defects, it shall not be reported as either sound or unsound, but its behavior shall be noted.

(*b*) The constancy of volume test shall be made as specified in Section 13.

III. PACKING AND MARKING.

Packing.

7. (*a*) *Kind of Package.*—The hydrated lime shall be packed in either cloth or paper bags.

(*b*) *Size of Package.*—The cloth package shall contain 100 lb. net weight of hydrated lime. The paper package shall contain 50 lb. net weight of hydrated lime.

Marking.

8. Each package shall be clearly marked to show the net weight of hydrated lime contained in the package, the name of the manufacturer, and the name of the brand, if any.

IV. INSPECTION AND REJECTION.

Inspection.

9. (*a*) All hydrated lime shall be subject to inspection.

(*b*) Hydrated lime may be inspected either at the place of manufacture or the point of delivery, as arranged at the time of purchase.

(*c*) The manufacturer shall furnish the inspector all reasonable facilities for inspection and sampling, which shall be so conducted as not to interfere with the operation of the works.

(*d*) The purchaser may make the tests to govern the acceptance or rejection of the hydrated lime in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

Rejection.

10. Unless otherwise specified, any rejection based on failure to pass tests prescribed in these specifications shall be reported within five working days from the taking of samples.

Rehearing.

11. Samples which represent rejected hydrated lime shall be preserved in air-tight containers for five days from the date of the test report. In case of dissatisfaction with the results of the tests, the manufacturer may make claim for a rehearing within that time.

V. METHODS OF TEST.

Method for Determining Fineness.

12. Fineness of hydrated lime shall be determined as follows:

Place 100 g. of the sample as received on a standard 30-mesh sieve having openings averaging 0.0198 in. This sieve shall be nested above a standard 200-mesh sieve having openings averaging 0.0029 in. Wash the material by means of a stream of water from a faucet. A small piece of rubber tubing attached to a water faucet will be found convenient. The velocity of the stream of water can be increased by pinching the tubing, but it should not be sufficient to cause any danger of splashing the sample over the sides of the sieve. Continue the washing until the water coming through the sieve is clear. Then dry the residue upon the 30-mesh sieve to constant weight in a drying oven whose temperature is maintained between 100 and 120° C. in an atmosphere free from carbon dioxide. Calculate the weight of this residue as percentage of the original sample. Then wash the material which has passed the 30-mesh sieve and remained on the 200-mesh sieve through the latter as described above. Treat the residue on this sieve in the same manner as described above for the 30-mesh sieve and add the percentage retained to the percentage residue on the 30-mesh sieve. The sum of these two shall be reported as the residue on the 200-mesh sieve.

Method for Determining Constancy of Volume.

13. Constancy of volume shall be determined as follows:

To 20 g. of the sample, add 100 g. of clean, washed, graded sand which shall all pass the No. 20 sieve and which shall all be retained on the No. 100 sieve. Mix thoroughly and add enough water to make a good plastic mortar of a rather dry consistency. Spread out on a clean glass plate, to form a layer about $\frac{1}{8}$ in. thick by about 4 in. square. The pat shall be of even thickness throughout, and not tapering at the edges. If the mortar is too dry to work well, add more water. Place this pat in a closet to set for 24 hours. The temperature in the closet should be between 65 and 75° F., and there should be free circulation of air in the closet, without allowing any direct draft to hit the pat. At the end of 24 hours remove the pat from the closet and soak it in water, until a film of water stands unabsorbed on the surface of the pat. Examine the pat carefully for cracks. If any are found, too much water was used in making the pat, and it should be discarded and a new one made.

Mix 20 g. of the sample with enough water to form a thick cream. Spread this out in a thin layer on the surface of the pat. Let it stand for 15 minutes to permit possible air bubbles to form. Trowel to a smooth even surface, making this skim coat as thin as possible without allowing the sand to show through. Put the pat back in the closet for another 24 hours, so that the skim coat can set. Examine carefully, to insure the absence of any cracks or pops. Provide a vessel partially filled with cold water, and having a perforated cover. Suspend the pat in this vessel in such a way that the water can boil without touching it. Gradually bring the water to a boil, and keep it boiling gently for 5 hours, the pat being surrounded by steam during this time. Turn out the fire, and permit the water to cool for at least 12 hours before the cover is removed from the vessel. The pat is then removed and examined for cracking, popping or disintegration.

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TENTATIVE SPECIFICATIONS
FOR
GYPSUM.[1]

Serial Designation: C 22 – 20 T.

These specifications are issued under the fixed designation C 22; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1919; REVISED, 1920.

Definition.

1. (*a*) Pure gypsum is calcium sulfate combined in crystallin form with two molecules of water.

(*b*) Its chemical formula is $CaSO_4 \cdot 2H_2O$.

(*c*) No material may be considered gypsum within the meaning of these specifications which contains more than 35.5 per cent by weight of impurities.

Testing.

2. The chemical and physical properties of gypsum shall be determined in accordance with the Tentative Methods for Tests of Gypsum and Gypsum Products (Serial Designation: C 26–20 T) of the American Society for Testing Materials.[2]

I. FORMS AND SIZES.

Forms and Sizes.

3. Gypsum may be sold in any of the following forms and sizes:

(*a*) *Run-of-Mine.*—The form in which it comes from the mine or quarry.

(*b*) *Crushed.*—Run-of-mine gypsum further reduced to sizes suitable for specific uses. Crushed gypsum may be sold as follows:

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1921, to Mr. V. G. Marani, Secretary of Committee C-11 on Gypsum, 111 W. Monroe St., Chicago, Ill.

[2] See p. 634.

> Crushed gypsum shall all pass through a 3-in. (7.5-cm.) ring; not more than 25 per cent shall pass through a 100-mesh screen, and not less than 10 per cent shall be retained on a $\frac{3}{16}$-in. (0.469-cm.) or equal mesh screen.

(*c*) *Ground.*—Crushed gypsum further reduced to sizes suitable for specific uses. Ground gypsum may be sold in any of the following sizes:

> No. 1.—Material of this size shall all pass a 14-mesh sieve, and not less than 85 per cent of it shall pass a 100-mesh sieve.
>
> No. 2.—Material of this size shall all pass a 14-mesh sieve, and not less than 60 nor more than 85 per cent of it shall pass a 100-mesh sieve.
>
> No. 3.—Material of this size shall all pass an 8-mesh sieve, and not less than 40 nor more than 60 per cent of it shall pass a 100-mesh sieve.

II. SAMPLING.

Sampling from Bulk.

4. When gypsum is shipped in bulk, samples of about 5 lb. (2.5 kg.) each shall be taken at regular intervals during the complete loading or unloading of the carrier, in such a way as to accumulate at least 200 lb. (90 kg.) of material. This shall be broken so that it will all pass a 1-in. (2.5-cm.) ring, thoroughly mixed, and reduced by quartering to provide not less than a 1-lb. (0.5-kg.) sample for the laboratory.

Sampling from Packages.

5. When gypsum is shipped in packages, at least 3 per cent of the packages shall be sampled. Samples shall be taken from both the surface and the center of the packages. These samples shall then be broken, mixed, and quartered as directed above.

Laboratory Samples.

6. All laboratory samples shall be placed immediately in an air-tight container and shipped to the laboratory for test.

III. CHEMICAL PROPERTIES.

Chemical Properties.

7. The chemical composition, within the limits prescribed by Section 1, shall be a matter of contract.

IV. PHYSICAL PROPERTIES.

Fineness.

8. Gypsum may be purchased either as run-of-mine, broken or crushed, or in any of the three sizes enumerated for ground

gypsum in Section 3 (*c*). Each package or each shipment, shipped for resale, shall be accompanied by a card or tag which shall contain the information required by Section 10.

V. PACKING AND MARKING.

Packing and Marking.

9. (*a*) Gypsum may be shipped either in packages or in bulk.

(*b*) When shipped in packages for resale, the following information shall be legibly marked on each package or on a tag of suitable size attached thereto:

Name of manufacturer;
Form and size of material;
Chemical analysis of the material, giving the minimum percentages of CaO and SO_3;
Net weight of package.

(*c*) When shipped in bulk, a card containing the required information shall be conspicuously placed in the carrier.

VI. INSPECTION AND REJECTION.

Inspection.

10. Inspection may be made either at the point of shipment or at the point of delivery. The inspector representing the purchaser shall have free access to the carriers being loaded for shipment to the purchaser. He shall be afforded all reasonable facilities for inspection and sampling, which shall be so conducted as not to interfere unnecessarily with the loading of the carriers.

Rejection.

11. Any rejection shall be based upon the specific cause of failure to conform to the requirements of these specifications, and shall be reported within ten working days from the receipt of the shipment by the consignee.

Rehearing.

12. Claims for rehearing shall be valid only if made within 20 working days from receipt of notice of specific cause for rejection.

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TENTATIVE SPECIFICATIONS FOR CALCINED GYPSUM.[1]

Serial Designation: C 23 – 20 T.

These specifications are issued under the fixed designation C 23; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1919; REVISED, 1920.

Definition. 1. Calcined gypsum is the product resulting from the partial dehydration of gypsum by means of heat.

Testing. 2. The chemical and physical properties of calcined gypsum shall be determined in accordance with the Tentative Methods for Tests of Gypsum and Gypsum Products (Serial Designation: C 26–20 T) of the American Society for Testing Materials.[2]

I. CLASSES AND SIZES.

Classes. 3. Calcined gypsum is divided into three classes on the basis of its purity, as follows:

Class A.—Containing not less than 88.4 per cent of $CaSO_4 \cdot \frac{1}{2}H_2O$. (These figures correspond to 90-per-cent purity in the gypsum.)

Class AA.—Containing not less than 71.7 per cent of $CaSO_4 \cdot \frac{1}{2}H_2O$, nor more than the similar quantities specified for

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1921, to Mr. V. G. Marani, Secretary of Committee C-11 on Gypsum, 111 W. Monroe St., Chicago, Ill.

[2] See p. 634.

Class A. (These figures correspond to 75-per-cent purity in the gypsum.)

Class AAA.—Containing not less than 60.5 per cent of $CaSO_4 \cdot \frac{1}{2}H_2O$ nor more than the similar quantities specified for Class AA. (These figures correspond to 64.5-per-cent purity in the gypsum.)

Sizes.

4. Calcined gypsum (all classes) may be sold in one of the following sizes:

> No. 1.—Material of this size shall all pass a 14-mesh sieve, and not less than 75 per cent of it shall pass a 100-mesh sieve.
>
> No. 2.—Material of this size shall all pass a 14-mesh sieve, and not less than 40 nor more than 75 per cent of it shall pass a 100-mesh sieve.

II. SAMPLING.

Sampling.

5. At least 3 per cent of the packages shall be sampled, and shall be so selected as to be representative of the contents of the shipment. Samples shall be taken from both the surface and the center of the packages. The material so obtained shall be thoroughly mixed and reduced by quartering to provide not less than a 15-lb. (7.5 kg.) sample for the laboratory.

Laboratory Samples.

6. All laboratory samples shall immediately be placed in an air-tight container and shipped to the laboratory for test.

III. CHEMICAL PROPERTIES.

Chemical Properties.

7. The chemical composition, within the limits prescribed by Section 3, shall be a matter of contract.

IV. PHYSICAL PROPERTIES.

Fineness.

8. Calcined gypsum may be purchased in any of the sizes enumerated for calcined gypsum in Section 4. Each package or each shipment, shipped for resale, shall be accompanied by a tag or card which shall contain the information required by Section 20.

Color.

9. Specification to be supplied by the committee when the information is available.

Plasticity.

10. Specification to be supplied by the committee when the information is available.

Time of Setting. 11. The time of set of calcined gypsum shall be suitable for the purposes intended, and shall conform to the provisions prescribed for such in the Tentative Specifications for Gypsum Plasters (Serial Designation: C 28 - 20 T) of the American Society for Testing Materials.[1]

Tensile Strength. 12. Calcined gypsum shall have a tensile strength of not less than 200 lb. per sq. in. (14 kg. per sq. cm.).

Compressive Strength. 13. Calcined gypsum shall have a compressive strength of not less than 1000 lb. per sq. in. (70 kg. per sq. cm.).

V. CALCINED GYPSUM FOR MOLDING OR CASTING.

Fineness. 14. Calcined gypsum for molding or casting shall all pass a 14-mesh sieve and not less than 75 per cent of it shall pass a 100-mesh sieve.

Color. 15. Specifications to be supplied by the committee when the information is available.

Plasticity. 16. Specifications to be supplied by the committee when the information is available.

Time of Setting. 17. Calcined gypsum for molding or casting shall set in not less than 10 minutes nor more than 40 minutes.

Tensile Strength. 18. Calcined gypsum for molding or casting shall have a tensile strength of not less than 200 lb. per sq. in. (14 kg. per sq. cm.).

Compressive Strength. 19. Calcined gypsum for molding or casting shall have a compressive strength of not less than 1000 lb. per sq. in. (70 kg. per sq. cm.).

VI. PACKING AND MARKING.

Packing and Marking. 20. Calcined gypsum may be shipped in either packages or in bulk.

(*a*) When shipped for resale, the following information shall be legibly marked on each package or on a tag of suitable size attached thereto:

Name of manufacturer;
Brand;
Description;
Net weight of package.

(*b*) When shipped in bulk, a card containing the required information shall be conspicuously placed in the carrier.

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[1] See p. 616.

VII. INSPECTION AND REJECTION.

21. Inspection may be made either at the point of shipment or at the point of delivery. The inspector representing the purchaser shall have free access to the carriers being loaded for shipment to the purchaser. He shall be afforded all reasonable facilities for inspection and sampling, which shall be so conducted as not to interfere unnecessarily with the loading of the carriers. **Inspection.**

22. Any rejection shall be based upon the specific cause of failure to conform to the requirements of these specifications and shall be reported within ten working days from the receipt of the shipment by the consignee. **Rejection.**

23. Claims for rehearing shall be valid only if made within 20 working days from receipt of notice of specific cause for rejection. **Rehearing.**

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TENTATIVE SPECIFICATIONS
FOR
GYPSUM PLASTERS.[1]

Serial Designation: C 28 - 20 T.

These specifications are issued under the fixed designation C 28; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1920.

Testing. 1. The chemical and physical properties of gypsum plasters shall be determined in accordance with the Tentative Methods for Tests of Gypsum and Gypsum Products (Serial Designation: C 26 - 20 T) of the American Society for Testing Materials.[2]

I. READY-MIXED GYPSUM PLASTER.

Definition. 2. Ready-mixed gypsum plaster is a plastering material in which the predominating cementitious material is calcined gypsum, and which is mixed at the mill with all the constituent parts in their proper proportion. It requires only the addition of water to make it ready for use.

Composition. 3. The following shall govern the composition of ready-mixed gypsum plaster for the desired coats:

(*a*) *Scratch or First Coat.*—Ready-mixed gypsum plaster used for scratch or first coat shall contain not more than two-thirds by weight of sand. The remainder shall contain not less than 75 per cent of its weight of calcined gypsum. The other 25 per cent of this remainder may consist of materials to control the working quality, setting time, and the fibering.[1]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1921, to Mr. V. G. Marani, Secretary of Committee C-11 on Gypsum, 111 W. Monroe St., Chicago, Ill.

[2] See p. 634.

(*b*) *Browning or Second Coat.*—Ready-mixed gypsum plaster used for browning or second coat shall contain not more than 75 per cent by weight of sand. The remainder shall contain not less than 75 per cent by weight of calcined gypsum. The other 25 per cent of this remainder may consist of materials to control the working quality, setting time, and the fibering.[1]

Time of Setting.

4. The time of set of ready-mixed gypsum plaster shall be as follows:

(*a*) *Scratch or First Coat.*—This plaster shall set in not less than $1\frac{1}{2}$ nor more than 7 hours.

(*b*) *Browning or Second Coat.*—This plaster shall set in not less than 2 nor more than 6 hours.

Tensile Strength.

5. The tensile strength of ready-mixed gypsum plaster shall be as follows:

(*a*) *Scratch or First Coat.*—This plaster shall have a tensile strength of not less than 75 lb. per sq. in. ($5\frac{1}{4}$ kg. per sq. cm.).

(*b*) *Browning or Second Coat.*—This plaster shall have a tensile strength of not less than 50 lb. per sq. in. ($3\frac{1}{2}$ kg. per sq. cm.).

II. NEAT GYPSUM PLASTER.

Definition.

6. Neat gypsum plaster is a plastering material in which not less than 85 per cent of the cementitious material is calcined gypsum mixed at the mill with other materials.

Composition.

7. Neat gypsum plaster shall contain not less than 85 per cent by weight of calcined gypsum. The remainder may consist of materials to control the working quality, setting time, and the fibering.[1]

Time of Setting.

8. Neat gypsum plaster shall set in not less than $1\frac{1}{2}$ hours.

Tensile Strength.

9. Neat gypsum plaster shall have a tensile strength of not less than 150 lb. per sq. in. ($10\frac{1}{2}$ kg. per sq. cm.).

III. GYPSUM WOOD-FIBER PLASTER.

Definition.

10. Gypsum wood-fiber plaster is a gypsum plaster in which wood fiber is used as an aggregate.

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[1] The U. S. Bureau of Standards is investigating the effect of Portland cement mixed in gypsum plasters. A report on these investigations is forthcoming.

Composition. 11. Gypsum wood-fiber plaster shall contain not less than 80 per cent by weight of calcined gypsum, and not less than 1 per cent by weight of wood fiber made from a non-staining wood. The remainder may consist of materials to control the working quality and setting time.[1]

Time of Setting. 12. Gypsum wood-fiber plaster shall set in not less than $1\frac{1}{2}$ nor more than 8 hours.

Tensile Strength. 13. Gypsum wood-fiber plaster shall have a tensile strength of not less than 125 lb. per sq. in. ($8\frac{3}{4}$ kg. per sq. cm.).

IV. CALCINED GYPSUM FOR FINISHING COAT.

Definition. 14. Calcined gypsum for finishing coat may, or may not, contain retarder. It may be sold in two grades, viz: "White" and "Gray."

Color. 15. Specifications for color to be determined by the committee when the information is available.

Fineness. 16. Calcined gypsum for finishing coat shall all pass a 14-mesh sieve, and not less than 60 per cent of it shall pass through a 100-mesh sieve.

Time of Setting. 17. Calcined gypsum for finishing coat when not retarded shall set in not less than 20 minutes nor more than 40 minutes, and when retarded shall set in not less than 40 minutes nor more than 6 hours.

Tensile Strength 18. Calcined gypsum for finishing coat shall have a tensile strength of not less than 200 lb. per sq. in. (14 kg. per sq. cm.).

V. PACKING AND MARKING.

Packing and Marking. 19. (*a*) Gypsum plasters shall be dry and free from lumps, and may be shipped either in packages or in bulk.

(*b*) When shipped for resale, the following information shall be legibly marked on each package or on a tag of suitable size attached thereto:

Name of Manufacturer.
Brand.
Description.
Net weight of package.

(*c*) When shipped in bulk, a card containing the required information shall be conspicuously placed in the carrier.

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[1] The U. S. Bureau of Standards is investigating the effect of Portland cement mixed in gypsum plasters. A report on these investigations is forthcoming.

VI. INSPECTION AND REJECTION.

Inspection. 20. Inspection may be made either at the point of shipment or at the point of delivery. The inspector representing the purchaser shall have free access to the carrier being loaded for shipment to the purchaser. He shall be afforded all reasonable facilities for inspection and sampling, which shall be so conducted as not to interfere unnecessarily with the loading of the carriers.

Rejection. 21. Any rejection shall be based upon the specific cause of failure to conform to the requirements of these specifications, and shall be reported within ten working days from the receipt of the shipment by the consignee.

Rehearing. 22. Claim for rehearing shall be valid only if made within twenty working days from receipt of notice of specific cause for rejection.

VII. SAND.

Quality of Sand. 23. The sand used for all plastering purposes shall conform to the following:

(*a*) *Impurities.*—It shall be free from salt, alkali, or other deleterious substances, and shall not contain more than 8 per cent by weight of loam, clay or silt.

(*b*) *Fineness.*—It shall, when dry, pass through an 8-mesh sieve and not less than 90 per cent of it by weight shall be retained on a 48-mesh sieve.

VIII. FIBER.

Quality of Fiber. 24. The fiber used in gypsum plasters shall conform to the following:

(*a*) *Hair.*—Hair shall be long, clean, cattle or goat hair, washed and pickered.

(*b*) *Wood Fiber.*—Wood-fiber shall be ground, crushed or shredded wood of uniform grade, free from splinters, coarse chips, and bark, and shall contain not more than 10 per cent of wood dust.

(*c*) *Other Fibers.*—Other materials used for fibers shall be clean, of good strength, and not more than $2\frac{1}{2}$ in. (6 cm.) in length.

IX. WATER.

Quality of Water. 25. The water used for mixing gypsum plasters shall be fresh, pure and clean.[1]

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[1] Trouble may occur from the presence of any excessive amount of mineral or organic substances in the water.

AMERICAN SOCIETY FOR TESTING MATERIALS

PHILADELPHIA, PA., U. S. A.

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INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE TEST
FOR
SLAGGING ACTION OF REFRACTORY MATERIALS.[1]

Serial Designation: C 17 - 19 T.

This test is issued under the fixed designation C 17; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917; REVISED, 1919.

Preparation of Samples.

1. Select three or more of the bricks to be tested. Draw upon the smooth or unbranded side a line bisecting each brick across the narrow dimension. Draw diagonals across each half. The points of intersection of the diagonals locate the centers of rings. Where samples do not conform to the standard 9 in. brick, one or more points may be located on any flat smooth surface, provided the centers of rings do not approach closer than 2 in. to any edge of that surface, and if more than one point is chosen, the centers lie not closer than 4½ in. from each other.

The rings shall be 2½ in. in inside diameter, and ½ in. deep, and with walls ½ in. thick. The rings shall be made of well-burned clay[2] and shall be cemented on the brick with a refractory

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[1] Criticisms of this Tentative Test are solicited and should be directed, preferably before January 1, 1921, to Mr. A. V. Bleininger, Chairman of Committee C-8 on Refractories, Bureau of Standards, Washington, D. C.

[2] The rings used are made from clay, molded under pressure, dried and burned. The mix from which the rings are made is as follows:

55 per cent, by weight, of highly refractory flint clay, calcined and ground to pass a 20-mesh sieve and remain on a 60-mesh sieve;

cement.[3] The brick surface enclosed within the ring shall be free from all foreign material.

Preparation of the Slag to be Used as a Solvent.

2. For general use a synthetic slag[4] shall be used as a solvent. This slag shall be ground until it will pass a 40-mesh sieve.

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45 per cent, by weight, of first-quality plastic fire clay ground to pass a 20-mesh sieve.

Approximately 9 per cent by weight of water is added to the above mix and the whole is then thoroughly mixed and finally rubbed through a 10-mesh sieve. The best results are obtained if at this point the mix is allowed to stand for a few days, precaution being taken to prevent evaporation of the water.

The rings are molded in a four-piece steel mold, Fig. 1. The two pieces *A* and *C* engage dowel pins in the base plate. In molding the rings, the various parts are first assembled. The sleeve *B* is then removed and a weighed amount of the prepared ring mix is placed in the space between the parts *A* and *C*, care being taken to spread the mix as uniformly as possible. Experiment will be necessary to determine the weight of clay mix necessary to give the proper sized ring. The sleeve *B* is then replaced and subjected to a downward pressure of approximately 700 lb. per sq. in. The mold is then removed from the press and inverted upon a solid support. The base plate is next taken off and the ring then ejected by pressure upon the parts *A* and *C*. The ring after removal is dried and burned to 1350° C. (2462° F.).

[3] The mix used in cementing the rings on the brick is as follows:

46.5 per cent, by weight, of first-quality fire clay ground to pass a 100-mesh sieve;
46.5 per cent, by weight, of first-quality silica brick ground to pass a 100-mesh sieve;
7 per cent, by weight, of sodium silicate (Baumé 50°).

Sufficient water is added to the above mix to give a sirupy consistency.

The position the ring is to occupy on the brick is first marked by running a pencil around both the inner and outer circumferences of the ring when laid in position, thus outlining the surface of the brick touched by the ring. On this marked surface a coating of the above cement about $\frac{1}{32}$ in. thick is applied with a brush and the ring firmly pressed into place with a circular or twisting motion, while the cement is still soft. If the surface of the brick is rough it may be necessary to coat the lower surface of the ring also before placing it upon the brick.

[4] For general use with this test, a synthetic slag has been developed of the following composition:

Silica (SiO_2)	19.00	per cent
Alumina, (Al_2O_3)	12.89	"
Iron Oxide (Fe_3O_4)	15.73	"
Lime (CaO),	33.50	"
Magnesia (MgO)	6.93	"
Manganese (MnO);	3.52	"
Sodium Oxide	8.50	"

Melting Point of above slag.... 1270° C.

The materials as weighed out to give a pound of melted slag are as follows:

Silica	72	grams.
Alumina	58	"
Ferric Oxide	80	"
Calicum Carbonate	304	"
Magnesium Oxide	39	"
Manganese Dioxide	24	"
Sodium Carbonate	66	"

Any multiple of the above quantity may be used.

Ground silica brick is used as a source of silica. All other materials are c. p. chemicals. All materials should be sufficiently fine to pass a 40-mesh sieve and after being weighed out must be carefully and thoroughly mixed. Melting is performed in a plumbago crucible at a temperature of approximately 1350° C. (2462° F.). The mix should be placed in the crucible before heating.

The slag when melted is poured into a suitable receptacle and cooled. After cooling, the slag is ground and is then ready for use.

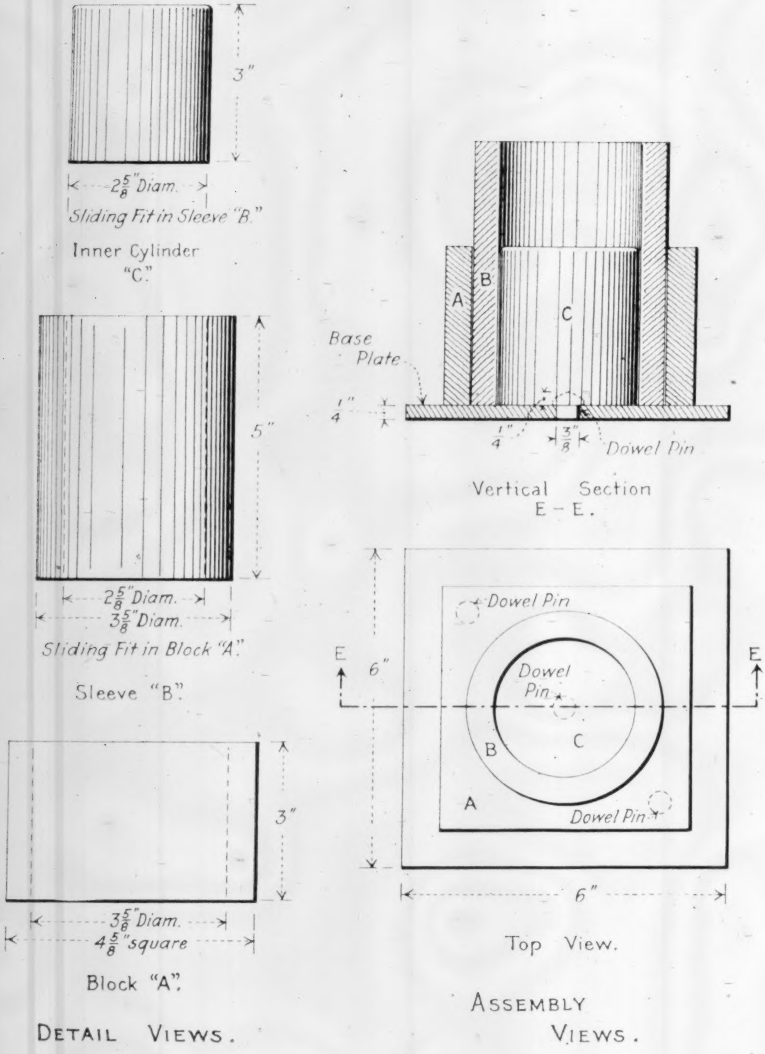
3"
2 5/8" Diam.
Sliding Fit in Sleeve "B."
Inner Cylinder "C."
5"
2 5/8" Diam.
3 5/8" Diam.
Sliding Fit in Block "A".
Sleeve "B".
3"
3 5/8" Diam.
4 5/8" square
Block "A".
DETAIL VIEWS.
A
B
C
Base Plate
1/4"
1/4"
3/8"
Dowel Pin
Vertical Section E - E.
Dowel Pin
E
E
6"
Dowel Pin
B
C
A
Dowel Pin
6"
Top View.
ASSEMBLY VIEWS.

FIG. 1.—Mold for Molding Rings.

The Heat Treatment.

3. The bricks shall be placed level on the hearth of a cold furnace and heated to 1350° C. (2462° F), attaining this temperature in a time not less than 5 hours. Thirty-five grams of powdered slag shall then be introduced by a metal spoon or equivalent device, avoiding scattering it upon the sides of the ring. The temperature shall then be held as nearly as possible at 1350° C. (2462° F.), for 2 hours; the fluctuations should not exceed 10° C. (18° F.) above or below this point. The furnace shall then be allowed to cool without removing the bricks. An oxidizing condition shall be maintained in the furnace throughout the test.

Measuring the Penetration.

4. When cold, the brick shall be sawed so that one of the sawed surfaces accurately bisects the center of the rings,[1] but it will be permissible to nick and break the bricks, provided they are broken so that there is no greater variation than $\frac{3}{16}$ in. from either side of a straight line through the center of the rings. The slag will be found to have discolored the brick into which it has penetrated more or less deeply. For measuring the area affected, a planimeter is used. The extreme outer margin of the discolored area shall be traced with the planimeter, closing on the trace of the plane of the original surface of the brick. The area in square inches thus obtained is the area of the brick penetrated and discolored by the slag.

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[1] The wheel used for sawing the brick is a silicon-carbide wheel, 12 in. in diameter, $\frac{1}{4}$ in. thick, $1\frac{1}{2}$ in. diameter of center hole, grit 16. This wheel is known as a vulcanite wheel

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TENTATIVE TEST
FOR
UNIT WEIGHT OF AGGREGATE FOR CEMENT CONCRETE.[1]

Serial Designation: C 29 – 20 T.

This test is issued under the fixed designation C 29; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1920.

1. The unit weight of fine, coarse, or mixed aggregates for cement concrete shall be determined by the following method:

Apparatus. 2. (*a*) The apparatus required consists of a cylindrical metal measure, a tamping rod, and a scale or balance, sensitive to 0.5 per cent of the weight of the sample to be weighed.

(*b*) *Measures.*—The measure shall be of metal, preferably machined to accurate dimensions on the inside, cylindrical in form, watertight, and of sufficient rigidity to retain its form under rough usage, with top and bottom true and even, and preferably provided with handles.

The measure shall be of $\frac{1}{10}$, $\frac{1}{2}$ or 1 cu. ft. capacity, depending on the maximum diameter of the coarsest particles in the aggregate, and shall be of the following dimensions:

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[1] Criticisms of this Tentative Test are solicited and should be directed, preferably before January 1, 1921, to Mr. A. T. Goldbeck, Secretary of Committee C-9 on Concrete and Concrete Aggregates, U. S. Bureau of Public Roads, Washington, D. C.

Capacity, cu. ft.	Inside Diameter, in.	Inside Height, in.	Minimum Thickness of Metal, U. S. Gage.	Diameter of Largest Particles of Aggregate, in.
$\frac{1}{10}$	6.00	6.10	No. 11	Under $\frac{1}{2}$
$\frac{1}{2}$	10.00	11.00	No. 8	Under $1\frac{1}{2}$
1	14.00	11.23	No. 5	Over $1\frac{1}{2}$

(*c*) *Tamping Rod.*—The tamping rod shall be a straight metal rod $\frac{3}{4}$ in. in diameter and 18 in. long, with one end tapered for a distance of 1 in. to a blunt bullet-shape point.

Calibrating the Measure.

3. The measure shall be calibrated by accurately determining the weight of water at 16°.7 C. (62° F.) required to fill it. The factor for any unit shall be obtained by dividing the unit weight of water at 16°.7 C. (62° F.)[1] by the weight of water at 16°.7 C. (62° F.) required to fill the measure.

4. (*a*) The sample of aggregate shall be room dry and thoroughly mixed.

Method.

(*b*) Fill the measure one-third full and level off the top with the fingers. Tamp the mass with the pointed end of the tamping rod twenty-five times, evenly distributed over the surface. Fill the measure two-thirds full and again tamp twenty-five times as before. Fill the measure to overflowing, tamp twenty-five times, then strike off the surplus aggregate, using the tamping rod as a straight edge.

In tamping the first layer do not permit the rod to forcibly strike the bottom of the measure. In tamping the second and final layers use only enough force to cause the tamping rod to penetrate the last layer of aggregate placed in the measure. No effort should be made to fill holes left by the rod when the aggregate is damp.

(*c*) Determine the net weight of the aggregate in the measure. The unit weight of the aggregate shall then be obtained by multiplying the net weight of the aggregate by the factor found as described in Section 3.

(*d*) Results with the same sample should check within 1 per cent.

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[1] The unit weight of water at 16°.7 C. (62° F.) is 62.355 lb. per cu. ft.

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TENTATIVE METHODS
FOR
CHEMICAL ANALYSIS OF LIMESTONE, LIME AND HYDRATED LIME.[1]

Serial Designation: C 25 – 19 T.

These methods are issued under the fixed designation C 25; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1919.

SOLUTION.

Solution. The sample, taken and prepared according to the requirements of the specifications for lime of the American Society for Testing Materials,[2] shall be treated as follows:

Weigh out 0.5 g. of the substance and, if a limestone or hydrated lime, ignite in a covered platinum crucible over a strong blast for 15 minutes, or longer if the blast is not powerful enough to effect complete decomposition within that time. Transfer to an evaporating dish, preferably of platinum for the sake of celerity in evaporation, mix to a thin slurry with distilled water, add 5 to 10 cc. of concentrated HCl and digest with aid of gentle heat and agitation until solution is complete.

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[1] Criticisms of these Tentative Methods are solicited and should be directed, preferably before January 1, 1921, to Mr. D. K. Boyd, Chairman of Committee C-7 on Lime, 1701 Walnut St., Philadelphia, Pa.

[2] Standard Specifications for Quicklime (Serial Designation: C 5) and for Hydrated Lime (Serial Designation: C 6), 1918 Book of A.S.T.M. Standards. See also Tentative Specifications for Masons' Hydrated Lime (Serial Designation: C 6–19 T), p. 605.

Solution may be aided by light pressure with the flattened end of a glass rod.[1] Then evaporate the solution to dryness, so far as this may be possible on the water bath.

DETERMINATION OF SILICA.

Silica.

Treat the residue, without further heating, at first with 5 to 10 cc. of concentrated HCl, which is then diluted to half strength or less, or pour upon the residue at once 15 to 20 cc. of HCl of half strength. Cover the dish and digest for 10 minutes on the water bath, after which filter the solution and thoroughly wash the separated silica with hot water. Evaporate the filtrate again to dryness, take up the residue without further heating with acid and water, separate the small amount of silica on another filter paper, and wash thoroughly with hot water. Transfer the papers containing the separated residue, wet, to a weighed platinum crucible, dry, ignite (first over a Bunsen burner until the carbon of the filter is completely consumed, then over the blast for 15 minutes) and weigh. Check this weight by further blasting for 10 minutes or as long as may be necessary to secure constant weight. If great accuracy is desired, treat the silica in the crucible with about 10 cc of HF and four drops of concentrated H_2SO_4 and evaporate over a low flame to complete dryness. Finally, blast the small residue for a minute or two, cool and weigh. The difference between this weight, and the weight previously obtained gives the weight of the silica.[2]

DETERMINATION OF IRON OXIDE AND ALUMINA.

Iron Oxide and Alumina.

Make about 250 cc. of the filtrate from the second evaporation for SiO_2 alkaline with NH_4OH, after adding HCl, if necessary, to insure a total volume of 10 to 15 cc. of concentrated HCl, and boil to expel excess of NH_3, or until the odor of NH_3 is barely noticeable. Wash the precipitated iron and aluminum hydroxides, after settling, once by decantation and slightly on the filter using hot water. Setting the filtrate aside, dissolve the precipitate from the paper in hot, dilute HCl, the solution passing into the beaker in which the precipitate was made, and wash the paper thoroughly with hot water. Precipitate the iron and alumina again as above, collect the precipitate on the filter used in the first instance and wash thoroughly with hot water. Then place the filter paper, with the precipitate, in a weighed platinum crucible, and burn off the paper over a low flame. Ignite the precipitate and finally blast 5 minutes (with care to prevent reduction), cool and weigh as $Al_2O_3+Fe_2O_3$.[1]

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[1] If anything remains undecomposed, it should be separated, fused with a little Na_2CO_3, dissolved in dilute HCl, and added to the original solution. A small amount of separated non-gelatinous silica is not to be mistaken for undecomposed matter.

[2] For ordinary control work in the plant laboratory, this correction may, perhaps, be neglected; the double evaporation must never be neglected.

DETERMINATION OF CALCIUM OXIDE.

Calcium Oxide.

Add a few drops of NH_4OH to the combined filtrate from the R_2O_3 precipitate, and bring the solution to boiling. To the boiling solution add 25 cc. of a saturated solution of ammonium oxalate, and continue the boiling until the precipitated CaC_2O_4 assumes a granular form; then allow it to stand 20 minutes, or until the precipitate has settled and the supernatent liquid is clear, filter and wash thoroughly with boiling water. Place the wet filter and precipitate in a platinum crucible, and burn off the paper over the small flame of a Bunsen burner. Ignite the residue, dissolve in hot dilute HCl, and make up the volume of the solution to 100 cc. with water. Add NH_4OH in slight excess and boil the liquid. If a small amount of Al_2O_3 separates, filter it out, wash with boiling water, ignite, weigh and add this weight to that found in the first determination. Then reprecipitate the lime by ammonium oxalate, allow to stand until settled, filter, wash thoroughly with boiling water,[2] and weigh as calcium oxide after ignition and blasting to constant weight in a covered platinum crucible, or determine by solution in dilute H_2SO_4 and titration with standard permanganate.[3]

DETERMINATION OF MAGNESIUM OXIDE.

Magnesium Oxide.

Acidify the combined filtrates from the calcium precipitates with HCl and concentrate on the steam bath to about 150 cc., add 10 cc. of saturated solution of Na (NH_4) HPO_4 and boil the solution for several minutes. Then cool to room temperature, and add NH_4OH drop by drop with constant stirring until the crystallin ammonium-magnesium ortho-phosphate begins to form and then in moderate excess, the stirring being continued for several minutes. Then allow to stand in a cool atmosphere for from 12 to 48 hours,[1] and filter. Dissolve the precipitate in hot dilute HCl, make up the solution with water to about 100 cc., add 1 cc. of a saturated solution of $Na\ (NH_4)\ HPO_4$, and NH_4OH drop by drop with constant stirring, until the precipitate is again formed as above described and the ammonia is in moderate excess. Then allow it to stand in a cool atmosphere for from 12 to 48 hours,[1] filter on paper or a Gooch crucible, wash with dilute ammonia containing ammonium nitrate,[2] ignite, cool, and weigh as $Mg_2P_2O_7$.

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[1] This precipitate also contains TiO_2, P_2O_5 and Mn_3O_4.

[2] The volume of wash water should not be large, about 125 cc.

[3] The accuracy of this method admits of criticism, but its convenience and rapidity demand its consideration. For details of method see under "Volumetric Determination of Calcium Oxide."

DETERMINATION OF TOTAL VOLATILE MATTER.

(LOSS ON IGNITION.)

Volatile Matter.

Weigh 1 g. of the properly prepared sample into a weighed platinum crucible, cover with the lid and heat for 5 minutes over a Bunsen burner, starting with a low flame and gradually raising to its full height. Then heat over a blast lamp for 15 minutes, or to constant weight.

DETERMINATION OF MECHANICAL MOISTURE.

Mechanical Moisture.

Weigh 1 g. of the properly prepared sample upon a tared watch glass, and heat in the drying oven (in an atmosphere free from CO_2) at 120° C. for two hours. Cool in a desiccator. and weigh. The loss in weight represents "Mechanical Moisture" or "Hydroscopic Water" at 120° C.

DETERMINATION OF CARBON DIOXIDE.

Carbon Dioxide.

Carbon dioxide is to be determined upon the properly prepared sample according to the method given in U S. Geologic Survey Bulletin No. 422, page 179. An illustration showing the arrangement of the component parts of the necessary apparatus is shown on page 180 of that Bulletin.

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[1] The less the amount of magnesium present, the longer the precipitate must be allowed to settle.

[2] Made by diluting NH_4OH with distilled water until the solution contains 2½ per cent of NH_3 by weight. Three or four drops of concentrated HNO_3 are then added.

With limestone, use a 0.5-g. sample; with burned lime, hydrated lime, etc., use a 5-g. sample.

Boil the weighed sample with dilute HCl in a small Erlenmeyer flask attached to an upwardly inclined condenser, whence, after passing through a drying system — calcium chloride, anhydrous copper sulfate to retain hydrogen sulfide from decomposable sulfides and any HCl that may pass over, then calcium chloride again — the carbon dioxide is caught by absorption tubes filled with soda-lime followed by calcium chloride. Of course, arrangement is made for a current of CO_2 free air with which to sweep out the apparatus before and after the experiment, and for a slow current during its continuance.

The results are very accurate and the determination can be quickly carried out.

The manipulations are as follows: Pour hot water upon the powder in the flask fitted with a separatory funnel and delivery tube; attach this to the condenser, and force a current of CO_2 free air through the whole system, except the weighed absorption tubes, until the original air has been displaced, the observation bulbs (Mohr Potash Bulbs containing sulfuric acid to show the rate of gas flow) being attached directly to the drying system. Then close the stop-cock in the separatory funnel, half fill the latter with HCl (1:1), replace the rubber stopper of the funnel, insert the absorption tubes between the drying system and the observation bulbs, and allow the acid to flow into the flask, slowly if there is much carbon dioxide, rapidly if there is but little. When effervescence diminishes in the former case, at once in the latter, light the burner under the flask and start the flow of water through the condenser. Keep the flame low, so as to secure steady but quiet ebullition, and do not interrupt the gas current although it should be reduced to a slow rate. With much carbon dioxide the rate of absorption is very readily noted by holding the hand to the soda-lime tubes, which become hot or warm where absorption is taking place. Sufficient time having elapsed, extinguish the flame, and increase the air current. When cool, disconnect the soda lime tubes from the apparatus and allow to stand in the balance case until two weights taken 30 minutes apart agree within 0.5 mg.

The soda lime for use in this determination must be porous, not hard and unabsorptive like that sometimes used for the combustion of nitrogenous organic substances.

DETERMINATION OF SULFURIC ANHYDRIDE.

Sulfuric Anhydride.

Weigh 2 g. of the properly prepared sample into a small, dry beaker and stir it up with 10 cc. of cold water until all lumps are broken up and the lighter particles are in suspension. Add 15 cc. of dilute HCl (1:1) and heat until solution is complete. Filter through a small paper and wash the residue thoroughly with hot water. Dilute the filtrate to 250 cc., heat to boiling, and add 10 cc. of a boiling 10-per-cent solution of barium chloride. Stir well and allow to stand over night. Filter, wash with boiling water, ignite and weigh as $BaSO_4$.

SEPARATION OF IRON AND ALUMINA.

Separation of Iron and Alumina.

Fuse the combined iron and aluminum oxides in a platinum crucible at a very low temperature with 3 to 4 g. of $KHSO_4$, or better $NaHSO_4$,[1] take up the melt with so much dilute H_2SO_4 that there shall be present no less than 5 g. absolute acid and enough water to effect solution on heating. Then evaporate the solution and eventually heat until acid fumes come off copiously. After cooling and redissolving in water, filter out the small amount of silica, wash, ignite, weigh, and correct by HF and H_2SO_4.[2] Reduce the filtrate by zinc, or preferably by H_2S, boiling out the excess of the latter afterwards while passing CO_2 through the flask, and titrate with permanganate.[3] The strength of the permanganate solution should not be greater than 0.0040 g. Fe_2O_3 per cubic centimeter. Subtract the weight of Fe_2O_3 obtained by this method from the total weight of the R_2O_3 precipitate, and report the remainder as Al_2O_3.

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[1] Or the corresponding pyrosulfates which are less troublesome and more effective than the acid sulfates.

[2] This correction for SiO_2 should not be made when the HF correction of the main silica determination has been omitted, unless that silica has been obtained by only one evaporation and filtration. After two evaporations, 1 to 2 mg. of silica are still to be found with the R_2O_3 precipitate.

[3] In this way only is the influence of titanium to be avoided and a correct result obtained for iron.

VOLUMETRIC DETERMINATION OF CALCIUM OXIDE.

Volumetric Determination of Calcium Oxide.

Make the filtrate from the iron and alumina precipitate alkaline with ammonia, boil, and add 25 cc. of a boiling saturated solution of ammonium oxalate.[1] Stir vigorously and allow to stand 15 minutes or until the precipitate has settled, filter on an 11-cm. paper, and wash ten times with hot water.[2] Transfer paper and precipitate to the beaker in which the precipitation was made, spreading the paper out against the upper portion of the beaker. Wash the precipitate from the paper with a jet of hot water, fold the paper and leave it adhering to the upper portion of the beaker. Add to the contents of the beaker, 50 cc. of dilute H_2SO_4 (1:10), dilute to a volume of 150 cc. and heat to a temperature of 80–90° C. Titrate with the standard permanganate solution (see following directions) until the pink end point is obtained. Now drop the folded filter paper (which has been adhering to the side of the beaker) into the liquid; the pink color of the latter will be discharged. Finish the titration by adding permanganate, a drop at a time, until the pink end point is again obtained. From the total quantity of standard permanganate solution used, calculate the percentage of calcium oxide.

PREPARATION OF STANDARD SOLUTION OF POTASSIUM PERMANGANATE.

Prepare a solution of potassium permanganate containing 5.64 g. of the pure crystallized salt in each liter. Such a solution will be of such strength that 1 cc. will approximately equal 0.005 g. of CaO.

The best and simplest way to prepare such a solution is to weigh out the required quantity of potassium permanganate and place in a bottle containing the proper volume of water a week or ten days before the solution is to be standardized. The bottle and its contents must be kept in a dark place and shaken every few hours for the first three or four days. When ready for standardization, siphon off the solution through a glass siphon into another bottle, leaving a depth of about one inch of solution in the original bottle.[1] Thoroughly mix the solution in the second bottle by shaking and standardize.[2]

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[1] It is better to use 3 g. of crystallized ammonium oxalate dissolved in 40–50 cc. boiling water immediately before using.

[2] **Use only 100–125 cc. water for this washing**

Dissolve 0.5 g. of sodium oxalate[3] in a 400-cc. beaker with 200 to 250 cc. of hot water (80–90° C.) and add 10 cc. of dilute H_2SO_4 (1:1) to the solution. Titrate at once with the permanganate solution being standardized, stirring vigorously and continuously. The permanganate solution must not be added more rapidly than 10 to 15 cc. per minute, and the last 0.5 to 1 cc. must be added dropwise, with particular care to allow each drop to be fully decolorized before the next is introduced. The excess of permanganate solution necessary to give the end point color is determined by running a blank determination in another beaker containing the same volume of acid and water present in the original beaker, and heated to the same temperature.[4] The value of the permanganate solution in grams of CaO per cubic centimeter of solution may be calculated from the following equations:

$$Na_2C_2O_4 + H_2SO_4 = Na_2SO_4 + H_2C_2O_4.$$

$$5\ H_2C_2O_4 + 2\ KMnO_4 + 8\ H_2SO_4 = 5\ H_2SO_4 + K_2SO_4 + 2\ MnSO_4 + 10\ CO_2 + 8\ H_2O.$$

$$5\ CaC_2O_4 + 2\ KMnO_4 + 8\ H_2SO_4 = 5\ CaSO_4 + K_2SO_4 + 2\ MnSO_4 + 10\ CO_2 + 8\ H_2O.$$

BLANK DETERMINATIONS.

In making chemical analysis of limestone, etc., by any of the above methods, blank determinations should be made on all reagents and the necessary corrections made in calculating the final results.

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[1] The siphon should not extend nearer than one inch from the bottom of the original bottle.

[2] This solution should be standardized at least once every week. It will be found more convenient to make a solution as above described and standardize it every week, than to attempt, by boiling and filtering, to make a solution which will not change.

[3] Sodium oxalate for standardization of potassium permanganate solution should be purchased from the U. S. Bureau of Standards, Washington, D. C. This material is sold by the Bureau as Standard Sample No. 40.

[4] When the end point is reached, the temperature of the solution should not be below 60° C.

AMERICAN SOCIETY FOR TESTING MATERIALS
PHILADELPHIA, PA., U. S. A.
AFFILIATED WITH THE
INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE METHODS
FOR
TESTS OF GYPSUM AND GYPSUM PRODUCTS.[1]

Serial Designation: C 26 – 20 T.

These methods are issued under the fixed designation C 26; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1919; REVISED, 1920.

I. DETERMINATION OF FREE WATER IN GYPSUM.

Free Water.

1. (*a*) Not less than 1 lb. of the entire sample as received shall be weighed, spread out in a thin layer in suitable vessel, placed in a drying oven, and dried at 45° C. for 2 hours. It shall then be cooled in an atmosphere free from moisture, and weighed again. The loss of weight corresponds to the free water, and shall be calculated to percentage of sample as received.

(*b*) The dried sample shall be stored in an air-tight container until used.

II. DETERMINATION OF FINENESS.

Fineness.

2. Fineness shall be determined by screening a known weight of the dried sample through screens of the specified sizes and weighing the amount of material retained on each screen. The

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[1] Criticisms of these Tentative Methods are solicited and should be directed, preferably before January 1, 1921, to Mr. V. G. Marani, Secretary of Committee C-11 on Gypsum, 111 W. Monroe St., Chicago, Ill.

material shall be shaken through the screen with as little abrasion as possible.

The size of the sample to be used in this determination shall depend upon the size of grain of the sample. If the sample will all pass a No. 3 screen, 100 g. will be sufficient; if the largest particles are more than 1 in. in diameter, at least 1000 g. must be used. With these limitations the size of sample to be used is left to the discretion of the operator.

NOTE.—The sizes of the screens to be used are given in the Tentative Specifications for Gypsum (C 22 - 20 T), for Calcined Gypsum (C 23 - 20 T) and for Gypsum Plasters (C 28 - 20 T) of the American Society for Testing Materials,[1] covering the particular product examined.

III. CHEMICAL ANALYSIS OF GYPSUM AND CALCINED GYPSUM.

Preparation of Sample.

3. Dry sample as in Section 1, and reduce about 10 g. until it all passes a 100-mesh sieve, using extreme care not to unduly expose the material to the action of moisture or to overheating. The sample shall be kept in an air-tight container until ready for use.

Combined Water.

4. Place 1 g. of the sample in a covered crucible and dry at 215 to 230° C. to constant weight. Calculate the loss of weight to percentage of sample as received and report as combined water.

Carbon Dioxide.

5. Place the residue obtained after drying, as described in Section 4, in a suitable flask and dissolve it in dilute HCl (not stronger than 1 : 4) in such a way that the gas evolved can be collected in either soda lime or caustic potash and weighed. The solution should be boiled for one minute, and a current of CO_2-free air kept passing through the apparatus for $\frac{1}{2}$ hour. The increase of weight of the soda lime or caustic potash corresponds to the weight of carbon dioxide, which is to be calculated to percentage of sample as received.

Silica and Insoluble.

6. Place 0.5 g. of the sample prepared as described in Section 3 in a porcelain casserole. Add about 25 cc. of 1:5 HCl, and evaporate to apparent dryness on a hot plate. Cool and add enough concentrated HCl to wet thoroughly. Add about 10 cc. of water, boil, filter, and wash. Put the filtrate back in the same casserole. Evaporate it to dryness and heat to about 120° C. for one hour. Cool. Add enough concentrated HCl to wet thoroughly. Add about 25 cc. of water, boil, filter, and wash.

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[1] See pp. 609, 612 and 616.

Transfer the two papers containing the two precipitates to the same crucible, ignite, and weigh. Calculate this weight to percentage of sample as received.

Iron and Alumina. 7. To the filtrate obtained as described in Section 6, add a few drops of HNO_3 and boil to insure oxidation of the iron. Add 2 g. of NH_4Cl previously dissolved in water. Make alkaline with NH_4OH. Digest hot for a few minutes until the precipitate coagulates. Filter, wash, ignite the precipitate and weigh as $Fe_2O_3+Al_2O_3$. Calculate this weight to percentage of sample as received. This precipitate may be further treated to separate the two oxides, but this is generally unnecessary.

Lime. 8. (*a*) To the filtrate obtained as described in Section 7, add 5 g. of $(NH_4)_2C_2O_4$ dissolved in water. Digest hot for ½ hour, making sure that the solution is always alkaline with NH_4OH. Filter, wash and ignite in a platinum crucible over a strong blast to constant weight. Calculate this weight to percentage of sample as received.

(*b*) *Alternative Method.*—To the filtrate obtained as described in Section 7, add 5 g. of $(NH_4)_2C_2O_4$ dissolved in water. Digest hot for ½ hour, making sure that the solution is always alkaline with NH_4OH. Filter and wash. Transfer the precipitate to a beaker, and wash the filter paper with hot dilute H_2SO_4, catching the washings in the same beaker. Heat gently to complete solution, adding more H_2SO_4 if necessary. While still warm, titrate with a solution of $KMnO_4$ containing 5.6339 g. per liter, until the pink color is permanent. The number of cubic centimeters of $KMnO_4$ used gives directly the percentage of lime in the dried sample. Recalculate to percentage of sample as received.

Magnesia. 9. To the filtrate obtained as described in Section 8 (*a*) or (*b*), add enough water to give a total volume of about 600 cc. Cool. Add 10 cc. of NH_4OH and 5 g. $NaNH_4HPO_4$ dissolved in water. Stir until precipitate begins to form. Let stand over night. Filter, wash with a 2.5-per-cent by weight solution of NH_4NO_3. Ignite and weigh. Multiply this weight by 40/111 to find the weight of MgO. Then calculate to percentage of sample as received.

Sulfur Trioxide. 10. Dissolve 0.5 g. of the sample prepared as described in Section 3 in 50 cc. of 1 : 5 HCl. Boil. Add 100 cc. of boiling water, and continue boiling for 5 minutes. Filter immediately and wash thoroughly with hot water. Boil, and while boiling, add slowly 20 cc. of a boiling 10-per-cent solution of $BaCl_2$. Digest hot for one hour, or until precipitate settles. Filter and wash. Dry carefully. Ignite over Bunsen burner at lowest heat possible until filter paper is burned off. Ignite at bright red heat for 15 minutes, and weigh. Multiply this weight by 80/233 to determine the weight of SO_3. Then calculate to percentage of sample as received.

Sodium Chloride.

11. Dissolve in boiling water a 1-g. sample (prepared as described in Section 3), put on the filter and wash with 250 cc. of boiling water, then titrate the filtrate. Add two or three drops of potassium chromate solution and titrate with an N/20 solution of silver nitrate. Each cubic centimeter of silver nitrate solution = 0.002923 g. of sodium chloride. Calculate to percentage of sample tested.

Calculation of Results.

12. By the methods given above, the results are obtained and reported in the following form:

	Per cent.
Free Water	
Combined Water	
Silica and insoluble, SiO_2	
Iron and alumina, R_2O_3	
Lime, CaO	
Magnesia, MgO	
Sulfur Trioxide, SO_3	
Carbon Dioxide, CO_2	
Sodium Chloride, NaCl	
	100.00 ±

NOTE.

Since it is frequently advisable to recalculate these results, that they may be more enlightening, the following method is submitted for consideration:

(*a*) Multiply percentage of MgO by 84/40, to find percentage of $MgCO_3$.

(*b*) Multiply the percentage of MgO by 44/40 to find the percentage of CO_2 as $MgCO_3$.

(*c*) Deduct CO_2 as $MgCO_3$ from the CO_2 determined.

(*d*) Multiply the CO_2 remaining by 100/44 to find percentage of $CaCO_3$.

(*e*) Add together the percentage of SiO_2, R_2O_3, $MgCO_3$, and $CaCO_3$, and report in the aggregate.

(*f*) Multiply the percentage of $CaCO_3$ by 56/100 to find the percentage of CaO as $CaCO_3$.

(*g*) From the total percentage of CaO, deduct the percentage of CaO as $CaCO_3$. The remainder may be called "available CaO."

(*h*) The "available CaO" should bear to the SO_3 a ratio of 7 to 10. Determine which (if either) is in excess.

(*i*) If the CaO is in excess, multiply the SO_3 by 7/10, and subtract the result from the "available CaO." The remainder is reported as "excess CaO."

(*j*) If the SO_3 is in excess, multiply the "available CaO" by 10/7 and subtract the result from the SO_3. The remainder is reported as "excess SO_3."

(*k*) Add together the "available CaO," and the SO_3, and subtract the "excess CaO" or "excess SO_3." The remainder is $CaSO_4$.

(*l*) If the $CaSO_4$ is present as $CaSO_4 \cdot \frac{1}{2}H_2O$, the percentage of $CaSO_4$ should bear to the percentage of combined water a ratio of 136 to 9. Determine which (if either) is in excess.

(*m*) If the $CaSO_4$ is in excess some of it is present in the anhydrous form. Multiply the percentage of combined water by 136/9 to find the percentage of $CaSO_4$ as $CaSO_4 \cdot \frac{1}{2}H_2O$. The difference between the total $CaSO_4$ and the percentage of $CaSO_4$ as $CaSO_4 \cdot \frac{1}{2}H_2O$, is the $CaSO_4$ in the anhydrous form.

(*n*) If the water is in excess, some of the $CaSO_4$ is present as gypsum. Let x = percentage of $CaSO_4 \cdot \frac{1}{2}H_2O$, and y = percentage of $CaSO_4 \cdot 2H_2O$. Then $x+y$ = percentage of $CaSO_4$ (as found in *k*) + percentage of water.

$$\frac{9x}{136}+\frac{36y}{172} = \text{percentage of combined water.}$$

Solve these equations for x and y. Report x as percentage of "calcined gypsum," $CaSO_4 \cdot \frac{1}{2}H_2O$. Report y as percentage of gypsum, $CaSO_4 \cdot 2\,H_2O$.

Having made these calculations, the result may be reported as follows:

	Per cent.
Gypsum, $CaSO_4 + 2H_2O$	
Calcined gypsum, $CaSO_4 + \frac{1}{2}H_2O$	
Anhydrite, $CaSO_4$	
Excess CaO or Excess SO_3	
Sodium chloride, NaCl	
Other ingredients	
	100.00 ±

The presence of the different forms of $CaSO_4$ may be corroborated by a microscopic examination.

IV. MICROSCOPIC EXAMINATION OF GYPSUM AND CALCINED GYPSUM.

Microscopic Examination.

13. The microscopic examination of gypsum products presupposes a thorough knowledge of petrography and the

developments in technique in this field. The distinctions between substances depend on their optical and crystallographic properties, so that when the individual crystallites of substances are minute, and above all when they possess similar properties, the microscopic examination leads at best to only qualitative results. It is, however, of great value in conjunction with the chemical analysis, since it furnishes proof of the state of combination of the radicals determined by chemical means.

The compounds met with in an examination of gypsum products are gypsum (with impurities which may consist of clay, quartz, or calcium carbonate), $CaSO_4\cdot\frac{1}{2}H_2O$, soluble anhydrite, insoluble anhydrite, lime and calcium hydroxide. Other siliceous, argillaceous and organic materials are frequently present as added foreign material, but their compositions and properties are variable and hence it is not within the scope of these methods to discuss them.

Gypsum.

14. *Gypsum* ($CaSO_4\cdot 2H_2O$) is noted in two varieties, selenite and alabaster, of which only the latter is of importance in the manufacture of gypsum products. It is noted in small grains, which may be irregular and may also show an attempt at prismatic development. Twinning may also be observed, the extinction is usually inclined and large extinction angles are usually noted. The indices of refraction for sodium light are $\alpha = 1.521$, $\beta = 1.523$ and $\gamma = 1.530$. The double refraction ($= 0.009$) is fairly weak and first order white to yellow interference colors are generally observed. The plane of the optic axis is parallel to *b* (010). The optical character is positive and the dispersion for red is greater than that for violet.

The impurities are often clay, $CaCO_3$, or silica. Clay is a very indefinite term applied to certain hydrous silicates of alumina, of which kaolin is the most important. Kaolin may be distinguished from gypsum by its higher indices ($\beta = 1.55$). Amorphous clay material may be distinguished by its isotropy with crossed nicols. Quartz has a higher index than gypsum ($\epsilon = 1.553$; $\omega = 1.544$) and is uniaxial, optically positive. Calcite is easily distinguishable by its extremely high double refraction, giving rise to a white of the higher order interference color. Furthermore, it is uniaxial, optically negative.

Calcined Gypsum.

15. *Calcined Gypsum* consists of either $CaSO_4 \cdot \frac{1}{2}H_2O$ or mixtures of $CaSO_4 \cdot \frac{1}{2}H_2O$ and soluble anhydrite.

(*a*) $CaSO_4 \cdot \frac{1}{2}H_2O$ is observed in very minute prismatic crystallites which are extremely intergrown. These crystallites apparently are not twinned in any definite manner, but are found in aggregates, the boundaries of which are those of the original gypsum crystals, and the small crystallites are orientated more or less parallel to the *C* crystallographic axis of the original crystal. The extinction is parallel and the mean index is about 1.54 (higher than that of gypsum). The interference colors are low gray, and the character of the principal zone is positive.

(*b*) Soluble anhydrite also occurs as minute needles exceedingly intergrown, the structure being practically identical with that of $CaSO_4 . \frac{1}{2}H_2O$. These crystals, however, possess an inclined extinction and a mean index of about 1.55. The double refraction is low, low-order gray and white being the interference colors noted.

Insoluble Anhydrite.

16. *Insoluble Anhydrite*, when first formed, has the same structure as that of $CaSO_4 \cdot \frac{1}{2}H_2O$ and soluble anhydrite, namely minute prismatic crystallites irregularly intergrown, the boundaries of whose aggregates are those of the original gypsum crystals. Both the indices of refraction and the double refraction are higher than those of soluble anhydrite, ($\alpha = 1.570, \beta = 1.575, \gamma = 1.613$). The extinction is parallel and the optical character is biaxial positive. In all determinable properties it seems to be identical with normal anhydrite, but it is extremely fine grained. Just below its dissociation point the small needle crystallites reconsolidate, and the resulting crystal is comparatively large, agreeing with soluble anhydrite in all its optical properties.

Lime.

17. *Lime* crystallizes in rounded isotropic grains of index equal to 1.83 and is thus easily distinguishable from all other constituents.

Calcium Hydroxide.

18. *Calcium hydroxide*, amorphous, occurs in isotropic grains with an index of 1.58. It is also recognized by White's calcium-phenolate test. Owing to insufficient water during hydration, it may show a strained condition which manifests itself by very low-gray interference colors.

V. PRECAUTIONS FOR PHYSICAL TESTS

Precautions for Physical Tests.

19. Gypsum products are peculiar in that their properties are very greatly affected by the small amounts of impurities which may be introduced by careless laboratory manipulation. In order to obtain concordant results, it is therefore absolutely essential to observe the following precautions:

(*a*) All apparatus shall be kept thoroughly clean. Especially shall all traces of set plaster be removed.

(*b*) Distilled water, free from chlorides and sulfates, shall be used throughout.

(*c*) Standard Ottawa sand shall be used throughout. This shall be prepared for use by washing it once with 1:4 HCl and four times with distilled water, and then drying it.

VI. NORMAL CONSISTENCY OF CALCINED GYPSUM.[1]

Normal Consistency.

20. In order that the results of testing samples of different plaster shall be directly comparable, it is necessary that all calcined gypsum be first brought to the same consistency, by the addition of the proper amount of water. An accurate method for determining normal consistency is the most important step in the standardizing of physical methods for testing cementing materials.

Apparatus.

21. For a description of the apparatus to be used for measuring normal consistency, reference is made to the accompanying illustration (Fig. 1) of the Southard viscosimeter which has been used with satisfactory results.

The apparatus consists of a brass cylinder of 2-in. (5.08 cm.) bore with a circular disk flange flush with its upper end. The screw actuating the piston is $\frac{5}{8}$ in. (1.59 cm.) in outside diameter, $\frac{1}{4}$-in. (0.635 cm.) pitch, right-hand square threads $\frac{1}{16}$ in. (0.159 cm.) deep. The top of the brass disk flange is etched with concentric circles which vary in diameter from 6 cm. up to 28 cm. by increments of 2 cm.

When in position for use the brass flange is to be maintained in a true horizontal position.

Method.

22. To prepare this viscosimeter for use see that the piston, cylinder walls and top of plate are clean. Then by turning the

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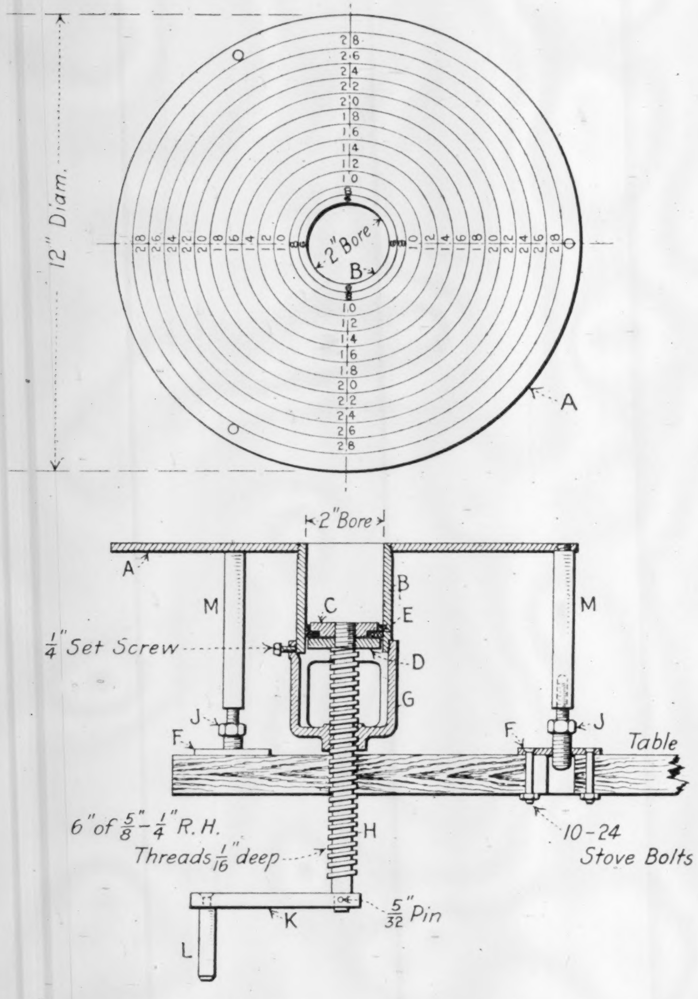
[1] Specifications for normal consistency of sanded mixtures to be supplied by the committee when the information is available.


12" Diam.
2.8
2.6
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
.8
2" Bore
B
A
2" Bore
A
B
M
M
C
E
$\frac{1}{4}$" Set Screw
D
G
J
J
F
F
Table
6" of $\frac{5}{8}$-$\frac{1}{4}$" R.H.
Threads $\frac{1}{16}$" deep
H
10-24
Stove Bolts
K
$\frac{5}{32}$" Pin
L

A; $\frac{3}{16}$" Hard Brass Plate Scale Disk.
B; 2" Ex. H. Seamless Brass Tube Cylinder.
C; Brass Piston Top.
D; " " Bottom.
E; Leather " Packing.
F; $\frac{3}{16}$" x 1" Flat Bar Steel Support Plate.
G; Brass Cage (Open on two Sides).
H; $\frac{5}{8}$" Hard Brass Piston Screw.
J; $\frac{1}{2}$" Hex. Brass Support Stud.
K; $\frac{3}{8}$" x $\frac{3}{4}$" C. R. S. Screw Lever.
L; $\frac{3}{8}$" Diam. C. R. S. Lever Handle.
M; $\frac{1}{2}$" Diam. C. R. S. Support Rod.

FIG. 1.—Southard Viscosimeter.

crank, bring the top of the piston exactly flush with the top of the plate. Then by reverse cranking make ten complete turns, which will lower the piston to a point $2\frac{1}{2}$ in. (6.35 cm.) below the top of the plate. Make a mixture of at least 300 g. total of dry calcined gypsum and water. Shake the calcined gypsum into the water through a No. 8-mesh sieve allowing it to soak two minutes. Stir to an even fluidity for not to exceed 30 seconds. Pour this mixture immediately into the well in the center of the plate of the viscosimeter, filling the well just flush with the top of the plate. Then immediately turn the crank at the bottom of the viscosimeter ten turns at the rate of one turn per second. The upward motion of the piston will cause the mixture to overflow into a circular pat, it being understood that the top face of the circular disk of the instrument is to be adjusted and maintained in a true horizontal plane. Next take the average of the quadrant readings on the concentric lines on the top of the plate.

A mixture is of normal consistency, if with this operation, it gives a circular pat averaging 9.7 cm. in diameter. The normal consistency shall be expressed as the number of cubic centimeters of water required to be added to 100 g. of the plaster under test in order to make the mixture of normal consistency.[1]

VII. WATER-CARRYING CAPACITY.

Water-Carrying Capacity.

23. The water carrying capacity is the amount of water, calculated as percentage by weight of the dry material, which is necessary to bring the mixture to normal consistency.

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[1] The following is recommended as a field method for the determination of normal consistency which will give fairly accurate results:

The apparatus shall consist of a piece of brass tubing 2 in. (5.08 cm.) in inside diameter and 4 in. (10.15 cm.) long, and a piece of plate glass about 8 in. (20.3 cm.) square. The brass tubing shall be cut off true and square at the ends, and to the exact length. Thoroughly wet the cylinder and glass plate by immersion in clean water Set the cylinder on end on top, and in the center of, the glass plate which is set and maintained in a true horizontal position.

Prepare a dry sample of calcined gypsum. Next make a mixture of calcined gypsum and water of sufficient quantity to slightly more than fill the cylinder. The mixture shall be made by adding the calcined gypsum to the water, allowing it to soak for two minutes. Now stir to an even fluidity for not to exceed 30 seconds, and at once pour this mixture into the cylinder so as to completely fill it level with the top.

Immediately raise the cylinder from the glass with a quick, straight and upward motion so as to withdraw it from the mixture within. This act will allow the mixture to leave the cylinder, assuming a cone-shaped circular pat upon the glass plate.

The normal consistency is a mixture which will give a circular pat averaging $4\frac{3}{4}$ in. (12 cm.) in diameter, and shall be expressed as the number of cubic centimeters of water required to be added to 100 g. of the plaster under test in order to make the mixture of normal consistency.

VIII. DETERMINATION OF DRY BULK.

Dry Bulk.

24. Place a 10-mesh screen above a 20-mesh screen and holding the two screens together at a height of 12 in. (30 cm.) above a perpendicular-sided receptacle of known volume and of about 400 cc. content.

Place the material under test on top of the 10-mesh screen and pass it through the 10-mesh screen and 20-mesh screen, filling the receptacle under the 12-in. head, then strike off and obtain the net weight of the contents in grams. Obtain the average of three tests according to this method and express the average result in cubic centimeters per 100 g. Dry Bulk is the volume in cubic centimeters occupied by 100 g. of dry material.[1]

IX. DETERMINATION OF WET BULK.

Wet Bulk.

25. Wet bulk is the volume in cubic centimeters occupied by a mixture of 100 g. of dry material mixed with water to normal consistency.

X. DETERMINATION OF TIME OF SETTING.

Time of Setting.

26. Mix 200 g. of the sample with enough water to make a paste of normal consistency. The directions for mixing are given under "Normal Consistency."

NOTE.—If the sample is a sanded mixture use 300 g. and mix to normal consistency for sanded mixture.

Fill a rubber mold with the paste, and test for time of set with a Vicat needle. The specifications for the mold and needle are given in the Standard Specifications for Portland Cement (Serial Designation: C 9) of the American Society for Testing Materials.[2]

When conducting the test, the needle is allowed to sink into the paste at frequent intervals. After each penetration, the needle must be wiped clean, and the paste moved slightly so that the needle will not strike the same hole twice.

The frequency of the penetrations will depend upon the character of the material. If the sample is not retarded, it should be tested every two minutes until nearly set, and then every minute. If the sample is retarded, the intervals at first may be as long as one hour, but in any case they must be so selected that the time of set is ascertained to the nearest minute.

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[1] Dry Bulk is expressed as the volume in cubic centimeters occupied by 100 g. of dry material instead of "grams per 100 cc." since Bulk is understood to mean Volume per Unit Weight rather than Weight per Unit Volume.

[2] 1918 Book of A.S.T.M. Standards.

Set is considered complete when the needle no longer penetrates to the bottom of the paste. The minutes elapsed, from the time when the sample was first added to the water, to the time when set is complete, is recorded as the time of set of the sample.

> *Caution:* For test to determine the time of set, it is absolutely essential that all dishes and utensils be clean. Especially must they be free from all traces of set gypsum. Use distilled water.

NOTE.—The relative merits of the "Penetration" and "Temperature Rise" methods for determining initial and final set, are being investigated by the U. S. Bureau of Standards.

XI. DETERMINATION OF TENSILE STRENGTH.

Tensile Strength.

27. Mix 500 g. of the sample to normal consistency. Cast into a five-gang briquette mold, of the shape and size used for testing Portland cement, see the Standard Specifications for Portland Cement (Serial Designation: C 9) of the American Society for Testing Materials.[1] Do not cast each briquette successively, but move the containing vessel back and forth over the molds while pouring continuously. Work the briquette slightly with the point of the trowel to remove air bubbles, and level off the briquettes. When sufficiently hard, remove and store in the room at a temperature of not less than 15°.6 C. (60° F.) nor more than 37°.8 C. (100° F.) for at least seven days. Weigh once a day. When the weight has become constant to within 0.1 per cent, proceed to test the specimens in a standard machine used for the determination of tensile strength.

NOTE.—When the material to be tested is a sanded mixture, use not less than 750 g. of the sample and mix to normal consistency for sanded mixture.

The average tensile strength shall be reported as the tensile strength of the material, except that if one or two briquettes vary more than 15 per cent from the average, the tensile strength shall be reported as the average of the remaining specimens. The tensile strength of all briquettes shall be reported.

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[1] 1918 Book of A.S.T.M. Standards.

XII. DETERMINATION OF COMPRESSIVE STRENGTH.

Compressive Strength.

28. Mix 2000 g. of the sample to normal consistency. Cast into five 2 by 4-in. split cylinders set plumb upon a metal or glass plate. Do not cast each cylinder successively, but move the containing vessel back and forth over the cylinders while pouring continuously. Work the cylinders slightly with the point of the trowel to remove air bubbles, and level off the top of the cylinders. When sufficiently hard, remove and store in the room at a temperature of not less than 15°.6 C. (60° F.) nor more than 37°.8 C. (100° F.) for at least seven days, and by weighing once a day, when the weight has become constant to within 0.1 per cent, proceed to test the specimens in a standard machine used for the determination of compressive strength.

NOTE.—When the material to be tested is a sanded mixture use not less than 3000 g. of the sample and mix to normal consistency for sanded mixture.

The average compressive strength shall be reported as the compressive strength of the material, except that if one or two of the cylinder specimens vary more than 15 per cent from the average, the compressive strength shall be reported as the average of the remaining specimens. The compressive strength of all the cylinders shall be reported.

XIII. DETERMINATION OF SAND-CARRYING CAPACITY OF CALCINED GYPSUM.

Sand-Carrying Capacity.

29. It is the sense of the committee that sand-carrying capacity cannot be defined by tensile strength. A method of measuring sand-carrying capacity should be based upon the working quality of the plaster when mixed with varying amounts of sand. The methods adopted should be independent of the nature of surface to which the sanded mixture is applied.

This problem may be solved by measuring the relative plasticities of sanded mixtures, and the committee will have it under consideration during the coming year.

AMERICAN SOCIETY FOR TESTING MATERIALS

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TENTATIVE METHOD
FOR
ULTIMATE CHEMICAL ANALYSIS OF CHROME ORES AND CHROME BRICK.[1]

Serial Designation: C 18 – 20 T.

This method is issued under the fixed designation C 18; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1920.

The sample shall be secured after the manner of any of the approved methods of sampling. If from ores or chrome-bearing refractories, it shall not be less than 10 lb., in small nut-size particles when sent to the laboratory. If from chrome brick, the sample shall consist of a small portion from the interior of from 15 to 25 bricks. This 10-lb. sample shall be crushed to pass a 20-mesh sieve and quartered until a sample of 100 g. is secured, which shall be ground to pass a 100-mesh sieve. From this portion, a smaller working sample shall be quartered and ground in an agate mortar to a very nearly gritless powder. In the case of hard burned brick or hard lump chrome ore the very fine grinding assists materially in solution of the sample.

Dry the fine, ground powder at 110° C. for not less than one hour. Cool in desiccator. Fuse 0.5 g. of the thoroughly dried sample in approximately 10 g. of fused potassium bi-sulfate in a platinum crucible. The usual cautions of a bi-sulfate fusion should be observed: that is, the flame turned very low so that the bi-sulfate just melts, increasing the flame so that the bi-sulfate remains in a liquid condition, very gradually increasing until the crucible reaches a dull red heat. The object of the slow heating is to retain the sulfuric acid, which is the effective part of the flux. The most refractory ores should be thoroughly fused in $1\frac{1}{2}$ to 2 hours. Remove the crucible from the burner and allow to cool in the air. The bi-sulfate melt will shrink from the crucible and may be removed easily in one cake. Dissolve the fusion in 200 cc. hot HCl (1 : 1), boiling until the solution acquires a clear, bright green color. Transfer the solution to a porcelain evaporating dish and evaporate to dryness on a water bath. Bake at exactly 120° C. until free from hydrochloric acid fumes. Moisten with hot HCl (1 : 1), evaporate on water bath and bake a second time at 120° C. Dissolve in 200 cc. hot dilute HCl (1:1), and filter out the silica. Ignite and weigh the silica in a platinum crucible. Add two drops concentrated H_2SO_4 and sufficient HF to remove all silica. Evaporate, ignite and weigh. The difference gives the amount of silica present in the sample. Should there be any appreciable residue left in the crucible it should be fused with a small amount of fused $KHSO_4$ and added to the filtrate from the silica.

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[1] Criticisms of these Tentative Methods are solicited and should be directed, preferably before January 1, 1921, to Mr. A. V. Bleininger, Chairman of Committee C-8 on Refractories, Bureau of Standards, Washington, D. C.

This method, when adopted as standard, will be added to the present Standard Methods for Ultimate Chemical Analysis of Refractory Materials (Serial Designation: C 18 – 20), A.S.T.M. Standards Adopted in 1920.

Dilute the filtrate from the silica to about 500 cc. and precipitate iron, aluminum, chromium and titanium, if present, with NH_4OH, using care to have not more than two drops of NH_4OH in excess in order to avoid solution of chromium and aluminum hydroxide in the alkaline solution. On account of the relatively large amount of magnesium that is usually present in chrome ores and chrome brick it is advisable to dissolve the precipitate in hot dilute HCl and precipitate a second time. Filter out the combined hydroxides and dissolve them on the filter paper with HNO_3, catching the solution in a porcelain casserole. Add a few crystals of $KClO_3$ and evaporate the nitric solution, adding a crystal of $KClO_3$ from time to time until the chromium is completely oxidized, which is indicated by a change from a dull green to a brilliant orange color. Dilute this solution with hot water and again precipitate with NH_4OH, filtering as before. The filtrate contains a large percentage of the chromium, while the residue on the filter consists of iron and aluminum hydroxides and titanium, if present. Repeat the oxidation two or three times until the filtrate from the iron and aluminum hydroxide precipitation shows no further traces of chromium. Concentrate and combine the filtrates containing chromium to approximately 500 cc. Add H_2SO_3 until the liquid changes from a bright orange to a brilliant green color and heat to boiling. Add NH_4OH to precipitate chromium as hydroxide, having not more than two drops in excess, as stated above. Filter, wash well with hot water, ignite and weigh as Cr_2O_3. The iron and aluminum and titanium hydroxides are ignited and weighed in a platinum crucible. Fuse the combined oxides with a small amount of $KHSO_4$, following the same precautions as mentioned above. Dissolve the fusion in dilute H_2SO_4, reduce with H_2S and titrate the iron with standard permanganate solution. Determine the titanium present by the colorimetric method, as described in Section 16 of the Tentative Methods for Ultimate Analysis of Refractory Materials (C 18 – 18 T)[1] of the American Society for Testing Materials. Subtract the combined amounts of Fe_2O_3 and TiO_2 from the total weight of the three oxides and thus determine Al_2O_3. If titanium is absent, reduce the iron with metallic zinc and titrate with K_2MnO_4, which is a little quicker method than the H_2S reduction.

To the combined filtrates from the precipitations of iron, aluminum, chromium and titanium hydroxides add bromine, allow to stand for a few minutes and then add sufficient NH_4OH to precipitate the manganese hydroxide. Boil to concentrate the manganese hydroxide if any be present. Filter, ignite and weigh as Mn_3O_4. In the filtrate from the manganese add NH_4OH and $(NH_4)_2C_2O_4$. Heat to boiling and when the calcium oxide has settled, filter with the usual precautions. The calcium oxide may be determined by ignition or by the volumetric method. (Refer to the determination of calcium oxide as described in Section 17 of the Standard Methods for Ultimate Analysis of Refractory Materials (Serial Designation: C 18) of the American Society for Testing Materials.[1])

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[1] A.S.T.M. Standards Adopted in 1920.

Evaporate the filtrate from the calcium oxalate to dryness with HNO_3 to remove the excess of ammonium salts. Dissolve the residue in hot water, filter, allow to cool and determine MgO as described in Section 18 of the Standard Methods for Ultimate Chemical Analysis of Refractory Materials (Serial Designation: C 18) of the American Society for Testing Materials.[1]

Determine alkalies by the J. Lawrence Smith Method, as described in Section 19 of the Standard Methods for Ultimate Chemical Analysis of Refractory Materials (Serial Designation: C 18) of the American Society for Testing Materials.[1]

RAPID ROUTINE METHOD FOR THE ANALYSIS OF CHROME BRICK AND CHROME ORE.

The sample shall be secured after the manner of any of the approved methods of sampling. If from ores or chrome bearing refractories it shall not be less than 10 lb. in small nut-sized particles when sent to the laboratory. If from chrome brick, the sample shall consist of a small portion from the interior of from 15 or 25 bricks. This 10-lb. sample shall be crushed to pass a 20-mesh sieve and quartered, until a 4-oz sample is secured, which shall be ground to pass a 100-mesh sieve. From this portion a smaller working sample shall be quartered and ground in an agate mortar to a very nearly gritless powder. In the case of hard burned brick or hard lump chrome ore the very fine grinding assists materially in solution of the sample. Dry the fine, ground powder at 110° C. for not less than 1 hour. Cool in desiccator.

CHROMIUM.

Fuse 0.5 g. of the sample in 8 to 10 g. of sodium peroxide in a nickel or porcelain crucible over a Bunsen burner, being careful not to heat too strongly. When fused, leach out with cold water, boil 15 minutes to decompose any sodium peroxide. Cool and add 100 cc. of H_2SO_4 (1:1). Cool to tap-water temperature and titrate with ferrous ammonium sulfate and potassium permanganate. Time $\frac{1}{2}$ to $\frac{3}{4}$ hour.

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[1] A.S.T.M. Standards Adopted in 1920.

SILICA AND IRON.

Fuse 0.5 g. of the sample in a nickel crucible over a Bunsen burner. Leach out with cold water, make acid with HCl and evaporate to dryness. Take up with 200 cc. water and add 10 cc. HCl. Filter off silica and wash well with hot water and hot dilute HCl. For high silica a second evaporation is necessary. The filtrate or combined filtrate is made alkaline with sodium hydroxide and about 5 cc. of bromine added. The mass is allowed to digest for ½ hour on a steam bath. This oxidizes the iron and chromium, precipitates the iron and dissolves the chromium and aluminum. After precipitating the iron twice it is filtered off on an asbestos plug and washed well with hot water. This precipitate of iron may be dissolved off the plug with hot HCl (1:1) and determined by the stannous chloride reduction, and permanganate method.

A blank should be run in conjunction with this method and deductions made when necessary to determine the purity of the chemicals used.

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TENTATIVE METHOD
FOR
DETERMINATION OF VOIDS IN FINE AGGREGATE FOR CEMENT CONCRETE.[1]

Serial Designation: C 30 – 20 T.

This method is issued under the fixed designation C 30; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1920.

Formula for Voids.

1. The voids in fine aggregate for cement concrete shall be determined by the formula:

$$\text{Percentage of Voids} = \frac{(\text{Sp. gr.} \times 62.355) - \text{Wt.}}{\text{Sp. gr.} \times 62.355} \times 100$$

Symbol "Sp. Gr."

2. The symbol "Sp. gr." represents the Apparent Specific Gravity of the fine aggregate as determined by the Standard Test for Determination of Apparent Specific Gravity of Sand, Stone and Slag Screenings, and Other Fine Non-Bituminous Highway Materials (Serial Designation: D 55) of the American Society for Testing Materials.[2]

Weight of Water.

3. The quantity 62.355 is the weight in pounds of one cubic foot of water at the standard temperature of 16°.7 C. (62° F.)

Symbol "Wt."

4. The symbol "Wt." represents the weight in pounds per cubic foot of the fine aggregate as determined by the Tentative Test for Unit Weight of Aggregate for Cement Concrete (Serial Designation: C 29 – 20 T) of the American Society for Testing Materials.[3]

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[1] Criticisms of this Tentative Method are solicited and should be directed, preferably before January 1, 1921, to Mr. A. T. Goldbeck, Secretary of Committee C-9 on Concrete and Concrete Aggregates, U. S. Bureau of Public Roads, Washington, D. C.

[2] A.S.T.M. Standards Adopted in 1919.

[3] See p. 624.

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TENTATIVE METHODS
FOR
MAKING AND STORING SPECIMENS OF CONCRETE IN THE FIELD.[1]

Serial Designation: C 31 - 20 T.

These methods are issued under the fixed designation C 31; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1920.

1. The methods herein specified apply to molding and storing of test specimens of concrete sampled from concrete being used in construction. **Scope.**

2. The test specimens shall be cylindrical in form with the length twice the diameter. In general a mold whose diameter is not less than four times the diameter of the largest size aggregate shall be used. (The sizes most commonly used are 6 by 12-in. and 8 by 16-in. cylinders.) **Size and Shape of Specimen.**

3. (*a*) The molds shall be cylindrical in form, made of non-absorbent material, and shall be substantial enough to hold their form during the molding of the test specimens. They shall not vary in diameter more than $\frac{1}{16}$ in. in any direction, nor shall they vary in height more than $\frac{1}{16}$ in. from the height required. They shall be substantially water tight so that there will be no leakage of water from the test specimen during molding. **Molds.**

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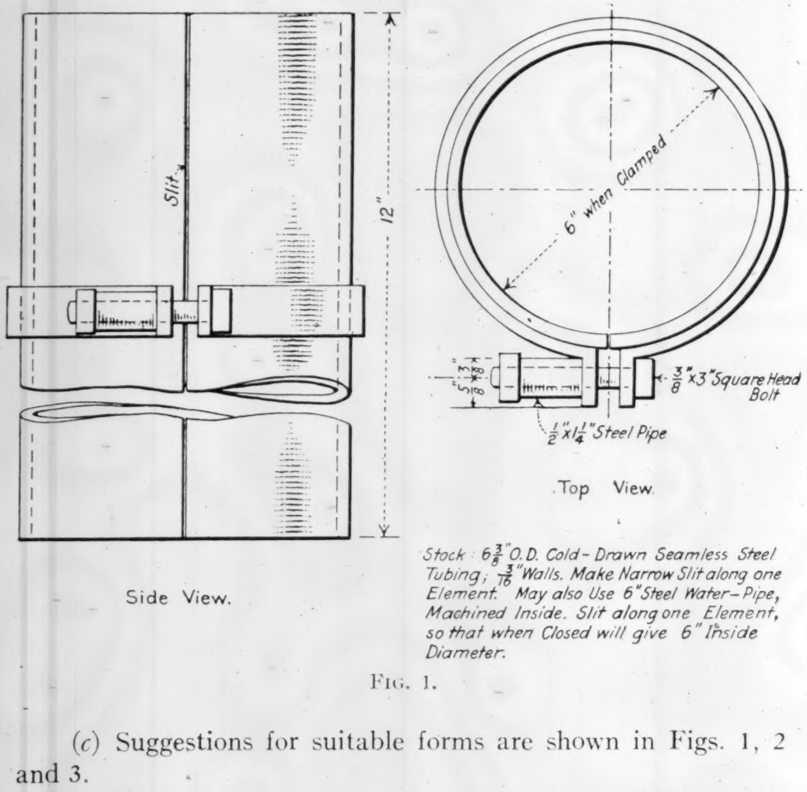
[1] Criticisms of these Tentative Methods are solicited and should be directed, preferably before January 1, 1921, to Mr. A. T. Goldbeck, Secretary of Committee C-9 on Concrete and Concrete Aggregates, U. S. Bureau of Public Roads, Washington, D. C.

(*b*) Each mold shall be provided with a base plate having a plane surface and made of non-absorbent material. This plate shall be large enough in diameter to properly support the form without leakage. Plate glass or planed metal are satisfactory for this purpose. A similar plate should be provided for covering the top surface of the test specimen after being molded.



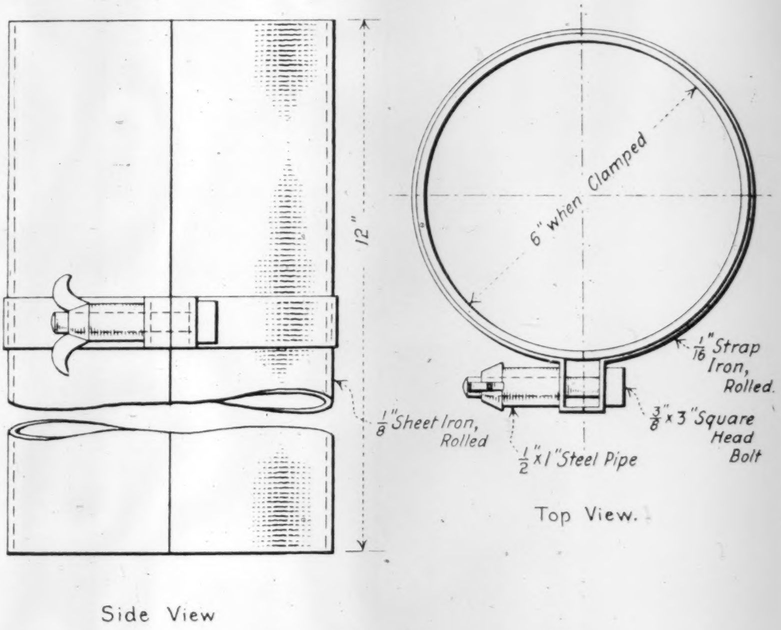
Stock: 6 3/8" O.D. Cold-Drawn Seamless Steel Tubing; 3/16" Walls. Make Narrow Slit along one Element. May also Use 6" Steel Water-Pipe, Machined Inside. Slit along one Element, so that when Closed will give 6" Inside Diameter.

FIG. 1.

(*c*) Suggestions for suitable forms are shown in Figs. 1, 2 and 3.

Sampling of Concrete. 4. (*a*) Concrete for the test specimens shall be taken immediately after it has been placed in the work. All the concrete for each sample shall be taken from one place. A sufficient number of samples—each large enough to make one test specimen—shall be taken at different points so that the test specimens made from them will give a fair average of the concrete placed in that portion of the structure selected for tests. The location from which each sample is taken shall be noted clearly for future reference.

(*b*) In securing samples, the concrete shall be taken from the mass by a shovel or similar implement and placed in a large pail or other receptacle, for transporting to the point of molding. Care shall be taken to see that each test specimen represents the total mixture of the concrete at that place. Different samples shall not be mixed together but each sample shall make one specimen.



Top View.

Side View

FIG. 2.

Molding the Specimens.

5. (*a*) The pails or other receptacles containing the samples of concrete shall be taken as quickly as possible to the place selected for molding test specimens. To offset segregation of the concrete occurring during transportation, each sample shall be dumped into a non-absorbent water-tight receptacle and, after slight stirring, immediately placed in the mold.

(*b*) The test specimens shall be molded by placing the concrete in the form in layers approximately 4 in. in thickness. Each layer shall be puddled with 25 to 30 strokes with a $\frac{5}{8}$ to $\frac{3}{4}$-in. bar about 2 ft. long, tapered slightly at the lower end. After puddling the top layer, the surface concrete shall be struck off with a trowel and covered with the top cover plate which will later be used in capping the test specimens.

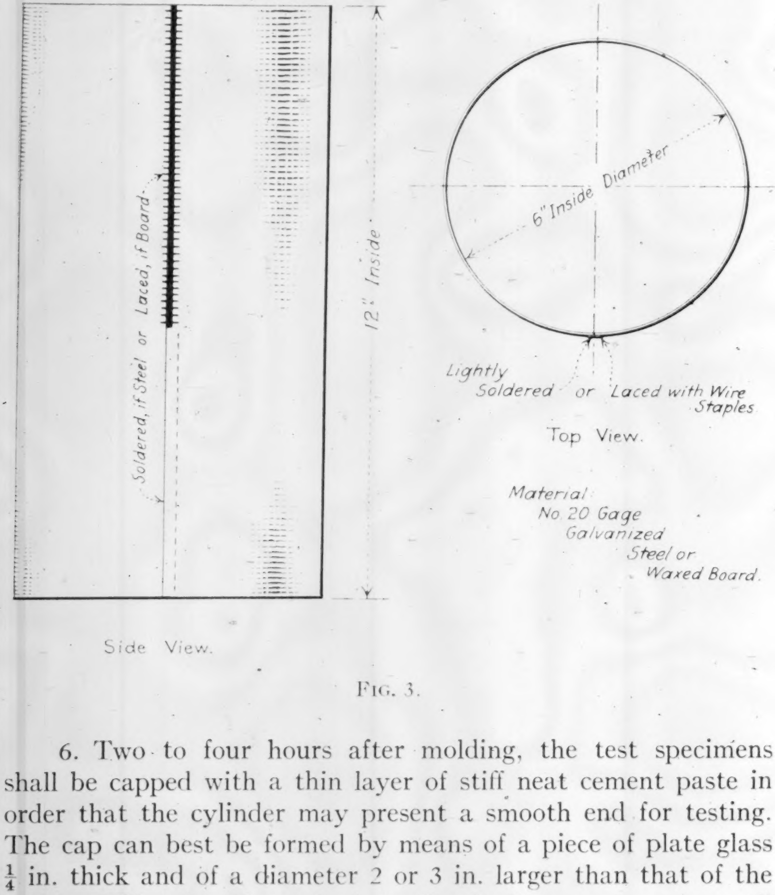

Soldered, if Steel or Laced, if Board
12" Inside
Side View.
6" Inside Diameter
Lightly Soldered or Laced with Wire Staples
Top View.
Material No. 20 Gage Galvanized Steel or Waxed Board.

FIG. 3.

Capping Specimens. 6. Two to four hours after molding, the test specimens shall be capped with a thin layer of stiff neat cement paste in order that the cylinder may present a smooth end for testing. The cap can best be formed by means of a piece of plate glass $\frac{1}{4}$ in. thick and of a diameter 2 or 3 in. larger than that of the mold. This plate is worked on the fresh cement paste until it rests on top of the form. The cement for capping should be mixed to a stiff paste some time before it is to be used in order to avoid the tendency of the cap to shrink. Adhesion of the concrete to the top and bottom plates can be avoided by oiling the plates or by inserting a sheet of paraffined tissue paper.

Removal of Specimens from Forms.

7. At the end of 48 hours the test specimens shall be removed from the molds and buried in damp sand except in case the molds shown in Fig. 3 are used; in this case test specimens may be buried in damp sand without removal of the mold, thus permitting shipping of the test specimens in the molds.

Storage of Specimens.

8. (*a*) The test specimens shall remain buried in damp sand until 10 days prior to the date of test. They shall then be well packed in damp sand or wet shavings and shipped to the testing laboratory, where they shall be stored either in a moist room or in damp sand until the date of test.

(*b*) Should a 7-day test be required, the test specimens shall remain at the works as long as possible to harden and then shall be shipped so as to arrive at the laboratory in time to make the test on the required date.

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TENTATIVE DEFINITIONS
OF
TERMS RELATING TO THE GYPSUM INDUSTRY.[1]

Serial Designation: C 11 - 16 T.

These definitions are issued under the fixed designation C 11; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1916.

SYNOPSIS.

These definitions are divided into fifteen parts, under the following titles:

I. GYPSUM: ITS FORMS, FUNCTIONS AND PRODUCTS.

Giving the various forms in which gypsum is used, its functions in the various classes of products, and a list of these products classified according to these functions.

II. CEMENTITIOUS BASE PRODUCTS.

A development of the products classified according to the first function given under Part I.

III–VII.

A skeleton outline of the development of products classified according to the remaining functions given under Part I.

VIII. CLASSES, TYPES AND FORMS OF CEMENTITIOUS BASE PRODUCTS.

A development of the classes, types and forms of the products given in

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[1] Criticisms of these Tentative Definitions are solicited and should be directed, preferably before January 1, 1921, to Mr. V. G. Marani, Secretary of Committee C-11 on Gypsum, 111 W. Monroe St., Chicago, Ill.

Part II. The plan is to give the definition of each product as it is listed, it being the intention that this arrangement will show the reason for the adoption of certain terms, and for the avoidance of other terms.

IX–XIII.

To be a development, similar to Part VIII, of the classes, types and forms of the products given in Parts III–VII.

XIV. GLOSSARY.

Contains a list of the ingredients used in gypsum products with their definitions, and a list of terms the use of which should be avoided if possible.

XV. APPENDIX.

Contains a discussion of the reasons for the adoption or avoidance of all of the foregoing terms.

I. GYPSUM: ITS FORMS, FUNCTIONS AND PRODUCTS.

(*A*) FORMS.

Forms.

1. Gypsum is used in the arts in two forms:
   - (*a*) Uncalcined.
     - (1) Mass.
     - (2) Crushed.
     - (3) Ground.
   - (*b*) Calcined.

(*B*) FUNCTIONS.

Functions.

2. Gypsum is used to function in several distinct ways:
   - (*a*) As a cementitious base.
   - (*b*) As a chemical.
   - (*c*) As a pigment.
   - (*d*) As a filler.
   - (*e*) As a flux.
   - (*f*) As a (other functions to follow).

(*C*) PRODUCTS.

Products.

3. Gypsum is mixed with other materials in the following classes of products:
   - (*a*) As a cementitious base in
     - (1) Coatings—applied in plastic form.
     - (2) Bondings—applied in plastic form.

        (3) Structural products.
        (4) Cast products.
        (5) Pottery products.
    (*b*) As a chemical in
        (1) Fertilizers.
        (2) Portland-cement manufacture.
        (3) Sulfuric-acid manufacture.
        (4) Brewing industry.
    (*c*) As a pigment in
        (1) Paints, oil, or water.
    (*d*) As a filler in
        (1) Paper.
        (2) Cloth.
    (*e*) As a flux in
        (1) Brass melting.
    (*f*) As a carrier for
        (1) Paris green.

II. CEMENTITIOUS-BASE PRODUCTS.

(*A*) COATINGS.

Coatings. 4. Coatings applied in a plastic form are sub-divided as follows:

(*a*) *Plaster.*—A material used in a plastic state to form a hard covering for the *interior* surfaces, walls, ceilings, etc., of any building or structure. The word "plaster" is used without regard to the composition of the material, defining only its use and location of use as contrasted with the words "stucco" and "mortar."

For Gypsum Plaster, see Part VIII, Section 22 (*c*) *1*.

(*b*) *Stucco.*—A material used in a plastic state to form a hard covering for the *exterior* walls or other *exterior* surfaces of any building or structure. The word "stucco" is used without regard to the composition of the material, defining only its use and location of its use, as contrasted with the words "plaster" and "mortar."

For Gypsum Stucco, see Part VIII, Section 22 (*c*) *2*.

(*B*) BONDINGS.

Bondings.

5. Bondings applied in a plastic form are sub-divided as follows:

(*a*) *Mortar.*—A material used in a plastic state, becoming hard in place, to bond together such materials as brick, stone, tile, gypsum blocks, terra cotta, etc., in building walls, partitions, columns, foundations, piers, floors, and roof arches, etc. The word "mortar" is used without regard to the composition of the material, defining its use as a bonding material, as contrasted with the words "stucco" and "plaster."

For Gypsum Mortar, see Part VIII (*B*)—(Definition to follow.)

(*C*) STRUCTURAL PRODUCTS.

Structural Products.

6. Gypsum structural products are sub-divided as follows: (Definitions to follow.)

(*a*) *Gypsum Plaster Boards.*

(*b*) *Gypsum Blocks* are sub-divided as follows:
  (1) Floor tile.
  (2) Book tile.
  (3) Roof tile.
  (4) Partition blocks.
  (5) Furring tile.
  (6) Column covering.

(*c*) *Concrete* is sub-divided as follows:
  (1) Arches—floor and roof.

(*D*) CAST PRODUCTS.

Cast Products,

7. Gypsum cast products are sub-divided as follows: (Definitions to follow.)

(*E*) POTTERY PRODUCTS.

Pottery Products.

8. Gypsum pottery products are sub-divided as follows:

(Definitions to follow.)

III. CHEMICAL PRODUCTS.

(*A*) FERTILIZERS.

Fertilizers.

9. Gypsum fertilizers are sub-divided as follows:

(Definitions to follow.)

(*B*) PORTLAND-CEMENT MANUFACTURE.

Portland-Cement Manufacture.

10. The uses of gypsum in Portland-cement manufacture may be sub-divided as follows:

(Definitions to follow.)

(*C*) SULFURIC-ACID MANUFACTURE.

Sulfuric-Acid Manufacture.

11. The uses of gypsum in sulfuric-acid manufacture may be sub-divided as follows:

(Definitions to follow.)

(*D*) (Title to follow.)

12. The uses of gypsum in (another chemical process) may be sub-divided as follows:

(Definitions to follow.)

IV. PIGMENT PRODUCTS.

(*A*) COATINGS APPLIED WITH BRUSH.

Coatings Applied with Brush

13. Liquid gypsum coatings applied with a brush are sub-divided as follows:

(Definitions to follow.)

(*B*) (Title to follow.)

14. (Another pigment product) are sub-divided as follows:

(Definitions to follow.)

V. FILLER PRODUCTS.

(*A*) PAPER FILLERS.

15. Gypsum paper fillers are sub-divided as follows: **Paper Fillers.**

(Definitions to follow.)

(*B*) CLOTH FILLERS.

16. Gypsum cloth fillers are sub-divided as follows: **Cloth Fillers.**

(Definitions to follow.)

(*C*) (Title to follow.)

17. Gypsum (other fillers) are sub-divided as follows:

(Definitions to follow.)

VI. FLUX PRODUCTS.

(*A*) FOUNDRY-CORE FLUXES.

18. Gypsum foundry-core fluxes are sub-divided as follows: **Foundry-Core Fluxes.**

(Definitions to follow.)

(*B*) (Title to follow.)

19. Gypsum (other fluxes) are sub-divided as follows:

(Definitions to follow.)

VII. (Other) PRODUCTS.

(*A*) (Title to follow.)

20. Gypsum (other products) are sub-divided as follows:

(Definitions to follow.)

(*B*) (Title to follow.)

21. Gypsum (other products) are sub-divided as follows:

(Definitions to follow.)

VIII. CLASSES, TYPES AND FORMS OF CEMENTITIOUS BASE PRODUCTS.

(*A*) COATINGS.

Classes of Coatings.

22. *Classes.*—Gypsum coatings applied in plastic form (plasters and stuccoes) are divided into several classes depending upon the predominating cementitious material, as follows:

(*a*) *Lump-Lime Plaster and Stucco.*

1. *Lump-Lime Plaster.*—A plaster in which the predominating cementitious material is lime putty made by slaking quicklime at the job.
2. *Lump-Lime Stucco.*—A stucco in which the predominating cementitious material is lime putty made by slaking quicklime at the job.

(*b*) *Hydrated-Lime Plaster and Stucco.*

1. *Hydrated-Lime Plaster.*—A plaster in which the predominating cementitious material is hydrated lime. It may be either "job-mixed plaster" or "prepared plaster." (See Section 23.)
2. *Hydrated-Lime Stucco.*—A stucco in which the predominating cementitious material is hydrated lime. It may be either "job-mixed stucco" or "prepared stucco." (See Section 23 (*a*)*2*, or (*b*)*2*.)

(*c*) *Gypsum Plaster and Stucco.*

1. *Gypsum Plaster.*—A plaster in which the predominating cementitious material is calcined gypsum.

   (Frequently called "cement plaster," "hard wall plaster," "patent plaster," "calcined plaster," "rock-wall plaster," "stucco wall plaster," etc. The use of these terms should be avoided.)

2. *Gypsum Stucco.*—A stucco in which the predominating cementitious material is calcined gypsum.

(*d*) *Keene's-Cement Plaster and Stucco.*

1. *Keene's-Cement Plaster.*—A plaster in which the predominating cementitious material is Keene's cement.
2. *Keene's-Cement Stucco.*—A stucco in which the predominating cementitious material is Keene's cement.

(*e*) *Portland-Cement Plaster and Stucco.*

1. *Portland-Cement Plaster.*—A plaster in which the predominating cementitious material is Portland cement.
2. *Portland-Cement Stucco.*—A stucco in which the predominating cementitious material is Portland cement.

(*f*) *Natural-Cement Plaster and Stucco.*

1. *Natural-Cement Plaster.*—A plaster in which the predominating cementitious material is natural cement.
2. *Natural-Cement Stucco.*—A stucco in which the predominating cementitious material is natural cement.

Forms of Coatings.

23. *Forms.*—Plasters and stuccoes are divided into several forms depending upon the amount of mixing done at the mill of the producer as follows:

(*a*) *Job-Mixed Plaster and Stucco.*

1. *Job-Mixed Plaster.*—A plaster in which all the ingredients are mixed at the job.
2. *Job-Mixed Stucco.*—A stucco in which all the ingredients are mixed at the job.

(*b*) *Prepared Plaster and Stucco.*

1. *Prepared Plaster.*—A plastering material mixed at the mill by the producer with all the constituent parts in their proper proportion, with the exception of the aggregate which may or may not be incorporated with the mixture at the mill.

   Prepared plasters are sub-divided into "ready-mixed plasters" and "neat plasters." See definition of these plasters.

2. *Prepared Stucco.*—A stucco material mixed at the mill by the producer with all the constituent parts in their proper proportion, with the exception of the aggregate which may or may not be incorporated with the mixture at the mill.

   Prepared stuccoes are sub-divided into "ready mixed stucco" and "neat stuccoes." See definitions of these stuccoes.

3. *Ready-Mixed Plaster.*—A "prepared plaster" requiring only the addition of water to make it ready for use.

This term distinguishes "ready-mixed plaster" from "neat plaster."

4. *Ready-Mixed Stucco.*—A "prepared stucco" requiring only the addition of water to make it ready for use.

This term distinguishes "ready-mixed stucco" from "neat stucco."

5. *Neat Plaster.*—A "prepared plaster" requiring the addition of both the aggregate and water to make it ready for use.

This term distinguishes "neat plaster" from "ready-mixed plaster."

6. *Neat Stucco.*—A "prepared stucco" requiring the addition of both the aggregate and water to make it ready for use.

This term distinguishes "neat stucco" from "ready-mixed stucco."

Types of Coatings.

24. *Types.*—Plasters and stuccoes are divided into several types depending upon the following conditions:

(*a*) *Material Used as an Aggregate.*

1. *Sand Plaster and Sand Stucco.*

Sand Plaster.—A plaster in which sand is used as the aggregate. This expression is used without regard to either the cementitious material employed, or the place of mixing the ingredients.

This term distinguishes "sand plaster" from "pulp plaster."

Sand Stucco.—A stucco in which sand is used as the aggregate. This expression is used without regard to either the cementitious material employed, or the place of mixing the ingredients.

This term distinguishes "sand stucco" from "pulp stucco."

2. *Pulp Plaster and Pulp Stucco.*

Pulp Plaster.—A plaster in which pulp is used as the aggregate. This expression is used without regard to either the cementitious material employed or the place of mixing the ingredients.

This expression distinguishes "pulp plaster" from "sand plaster."

Pulp Stucco.—A stucco in which pulp is used as the aggregate. This expression is used without regard to either the cementitious material employed or the place of mixing the ingredients.

This expression distinguishes "pulp stucco" from "sand stucco."

3. *Fiber Plaster and Fiber Stucco.*

Fiber Plaster.—A plaster in which fiber is used as the aggregate. This expression is used without regard to either the cementitious material employed or the place of mixing the ingredients.

Fiber Stucco.—A stucco in which fiber is used as the aggregate. This expression is used without regard to either the cementitious material employed or the place of mixing the ingredients.

(*b*) *Number of Coats.*

1. *Two-Coat Work.* (Definition to follow.)
2. *Three-Coat Work.* (Definition to follow.)

First or Scratch Coat.—The first coat of plaster or stucco. It is applied directly to the lath or masonry surfaces to be covered, and is scratched before thoroughly dry to provide a better bond for the next coat.

Second or Browning Coat.—The second coat of plaster or stucco. Generally used only in three-coat work, but does sometimes mean the finishing coat in two-coat work.

(*c*) *Method of Application.*

1. *Dry Scratch Work.* (Definition to follow.)
2. *Doubled-up Work.* (Definition to follow.)
3. *Drawn Work.* (Definition to follow.)

(*d*) *Finish.*—The finish given to a plastered or stuccoed surface is sub-divided as follows:

Finish or White Coat.—The last coat of plaster or stucco. In three-coat work it is applied to the second coat, and in two-coat work it is applied to the first coat, and then sometimes known as the second coat.

1. *White Troweled or Smooth Finish.* (Definition to follow.)
2. *Sand-Float or Rough Finish.* (Definition to follow.)
3. *Pebble Dash Finish.* (Definition to follow.)
4. *Stippled Finish.* (Definition to follow.)

(*B*) BONDINGS.

Development of Part II (*B*), Section 5. Definitions to follow.

(*C*) STRUCTURAL PRODUCTS.

Development of Part II (*C*), Section 6. Definitions to follow.

(*D*) CAST PRODUCTS.

Development of Part II (*D*), Section 7. Definitions to follow.

(*E*) POTTERY PRODUCTS.

Development of Part II (*E*), Section 8. Definitions to follow.

IX. CLASSES, TYPES AND FORMS OF CHEMICAL PRODUCTS.

Development of Part III, Sections 9–12. Definitions to follow.

X. CLASSES, TYPES AND FORMS OF PIGMENT PRODUCTS.

Development of Part IV, Sections 13–14. Definitions to follow.

XI. CLASSES, TYPES AND FORMS OF FILLER PRODUCTS.

Development of Part V, Sections 15–17. Definitions to follow.

XII. CLASSES, TYPES AND FORMS OF FLUX PRODUCTS.

Development of Part VI, Sections 18–19. Definitions to follow.

XIII. CLASSES, TYPES AND FORMS OF (Other) PRODUCTS.

Development of Part VII, Sections 20–21. Definitions to follow.

XIV. GLOSSARY.

(*A*) DEFINITIONS OF INGREDIENTS OF GYPSUM PRODUCTS.

1. *Gypsum.*—Gypsum is a hydrous calcium sulfate, formula $CaSO_4.2H_2O$, which may contain varying percentages of silica, alumina, iron oxide, and carbonates of calcium and magnesium.

   Limitations as to percentages of impurities should be established.

2. *Uncalcined Gypsum.*—A synonym for gypsum.

   Generally used to mean the raw material as taken from the mine or quarry for commercial use.

3. *Mass Gypsum.*—(Definition to follow.)
4. *Crushed Gypsum.*—A form of uncalcined gypsum. The size (state size limitations), distinguishing it from "ground gypsum."
5. *Ground Gypsum.*—A form of uncalcined gypsum. The size (state size limitations), distinguishing it from "crushed gypsum."
6. *Calcined Gypsum.*—A product resulting from the partial or complete calcination of gypsum. A cementitious material often used in stuccoes, plasters, mortars, concretes, etc., as the active setting material.

   Chemically pure calcined gypsum has the formula $CaSO_4.H_2O$. The commercial material has the same impurities as gypsum; silica, alumina, iron oxide, and carbonates of calcium and magnesium. Limitations as to percentage of impurities should be established. Frequently called "Plaster of Paris," the use of which should be avoided. (See Part XIV, Glossary, Section 29.)

7. *Cement.*—A material or a mixture of materials having cementitious properties (as hydrated lime, Portland cement, calcined gypsum, natural cement, glue, asphalt, Keene's cement, etc.). The word "cement" is used without regard to the composition of the material, and does not define its use or location of use as do the words "stucco," "plaster" and "mortar."

8. *Concrete.*—A mixture of one or more cementitious materials (as Portland cement, hydrated lime, calcined gypsum, natural cement, etc.), with an aggregate of sand, broken stone, cinders, asbestos fiber, etc., which becomes a solid mass when the cementitious materials have hardened.

9. *Portland Cement.*—The product obtained by finely pulverizing clinker produced by calcining to incipient fusion an intimate and properly proportioned mixture of argillaceous and calcareous materials, with no additions subsequent to calcination excepting water and calcined or uncalcined gypsum.

Definition taken from Standard Specifications and Tests for Portland Cement (Serial Designation: C 9) of the American Society for Testing Materials.[1]

10. *Natural Cement.*—The finely pulverized product resulting from the calcination of an argillaceous limestone at a temperature only sufficient to drive off the caronbic acid gas.

Definition taken from Standard Specifications for Cement (Serial Designation: C 10) of the American Society for Testing Materials.[1]

11. *Keene's Cement.*—(Definition to follow.)

12. *Quicklime.*—A material the major part of which is calcium oxide or calcium and magnesium oxide, which will slake on the addition of water.

Definition taken from Standard Specifications for Quicklime (Serial Designation: C 5) of the American Society for Testing Materials,[1] where it is divided into two forms, "lump" and "pulverized." See definitions of "lump lime" and "pulverized lime."

Also known as "lime," "lump lime," "burned lime," "calcinde lime," the use of which terms should be avoided.

13. *Lump Lime.*—A form of quicklime. The size taken from the kiln without crushing or grinding, distinguishing it from "pulverized lime."

Definition taken from Standard Specifications for Quicklime (Serial Designation: C 5) of the American Society for Testing Materials.[1] The form of quicklime generally slaked at the job tc make "lime putty."

14. *Pulverized Lime.*—A form of quicklime; "lump lime" reduced in size to pass a $\frac{1}{4}$-in. screen, distinguishing it from "lump lime."

Definition taken from Standard Specifications for Quicklime

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[1] 1918 Book of A.S.T.M. Standards.

(Serial Designation: C 5) of the American Society for Testing Materials.[1] This form of quicklime is seldom slaked at the job to produce "lime putty."

15. *Hydrated Lime.*—A cementitious material often used in stucco, plaster, mortar, etc., as an active setting agent. Always prepared at the mill of the producer and never made at the job from quicklime.

The definition given in the Standard Specifications for Hydrated Lime (Serial Designation: C 6) of the American Society for Testing Materials[1] is as follows: "A dry flocculent powder resulting from the hydration of quicklime." Analysis required by these specifications permits only the amount of water necessary to satisfy chemical hydration. This makes production of hydrated lime impossible at the job.

16. *Lime Putty.*—The predominating cementitious material in lime plaster, lime stucco and lime mortar. Made by slaking "quicklime" with an excess of water, or by adding water to "hydrated lime." A white, cream-like, smooth plastic paste.

Also called "slaked lime," the use of which term should be avoided.

17. *Lime Paste.*—A synonym of "lime putty."
18. *Aggregate.*—The inert materials used as a filler in stucco, plaster, mortar, concrete mixtures, without regard to their function as a binding material.
19. *Fine Aggregate.*—(Definition to follow.)
20. *Filler.*—A synonym for "aggregate."
21. *Sand.*—(Definition to follow.)
22. *Pulp.*—A binder used in stucco and plaster. Made by grinding, crushing or shredding wood in a manner similar to that in preparing wood pulp in paper manufacture. One of the general classes of fiber binders.
23. *Binder.*—A material used in stucco and plaster to increase the tensile strength, intended to prevent cracking and crumbling.
24. *Fiber.*—A general class of material used as binders in stucco and plaster. May be of wood, asbestos, hemp, etc.
25. *Hair.*—A binder used in stucco and plaster. Obtained from goats, cattle or other animals. One of the general class of fiber binders.

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[1] 1918 Book of A.S.T.M. Standards.

26. *Asbestos.*—(Definition to follow.)

27. *Retarders.*—Any material used in stucco, plaster, mortar, concrete, etc., to reduce the rapidity with which the cementitious materials set.

28. *Accelerators.*—Any material used in stucco, plaster, mortar, concrete, etc., to increase the rapidity with which the cementitious materials set.

(*B*) TERMS, THE USE OF WHICH SHOULD BE AVOIDED IF POSSIBLE.

29. *Plaster-of-Paris.*—This term uses "plaster" in a sense not in agreement with the definition. Also, this material is wrongly considered to be plaster, resulting in misunderstandings. "Calcined gypsum" is the term that should be used. (See Part XIV, Glossary, Section 6.)

30. *Cement Plaster.*—The term lacks definiteness, as it has been used to mean both "gypsum plaster" and "Portland-cement plaster."

31. *Hard Wall Plaster.*—See Part XV, Appendix, Section 20.

32. *Rock Wall Plaster.*—See Part XV, Appendix Section 20.

33. *Patent Plaster.*—See Part XV, Appendix, Section 20.

34. *Calcined Plaster.*—See Part XV, Appendix, Section 20.

35. *Stucco Plaster.*—See Part XV, Appendix, Section 20.

36. *Wall Plaster.*—See Part XV, Appendix, Section 20.

37. *Stucco Wall Plaster.*—See Part XV, Appendix, Section 20.

38. *Ceiling Plaster.*—See Part XV, Appendix, Section 20.

39. *Dry Mortar.*

40. *Bag Mortar.*

41. *Plaster Mortar.*

42. *Stucco Mortar.*

43. *Lime.*—It has been misused to mean any cementitious lime material without regard to its chemical or physical nature, and now lacks specific meaning. Chemically pure lime (CaO) is seldom used in the arts. See definition of "quicklime."

44. *Burned Lime.*—See definition of "quicklime," Part XIV, Glossary, Section 12.

45. *Calcined Lime.*—See definition of "quicklime," Part XIV, Glossary, Section 12.

46. *Slaked Lime.*—See definition of "lime putty" or "lime paste," Part XIV, Glossary, Sections 16 or 17.

47. *Building Lime.*—See definition of "quicklime," "lump lime," "pulverized lime," "hydrated lime," Part XIV, Glossary, Sections 12-15.

48. *Land Plaster.*

APPENDIX.

XV. DEVELOPMENT OF DEFINITIONS.

(*A*) STUCCO.

Stucco.

1. The word "stucco" is derived from the old High German word "stuchhi" meaning "a crust" or "piece."

2. Webster's Unabridged Dictionary defines the "stucco" as "plaster of any kind used as a coating for walls; especially a fine plaster, composed of lime or gypsum, sand and pounded marble, used for internal decorations and fine work." From this it appears that "stucco" may mean a coating for either exterior or interior walls, with particular reference to interior ornamental work as moldings, cornices, etc.

3. Manufacturers have used the word stucco to mean different materials without regard to the location of the surface to which it is applied. The following shows how "stucco" has been used by various manufacturers.

(*a*) Atlas Wall Plaster Co., Louisville, Ky., produce "Atlas Stucco Finish" for interior finish only, which is a calcined gypsum product.

(*b*) Michigan Gypsum Co., Grand Rapids, Mich., produce "N. P. Brand Stucco" for interior finish only, which is a calcined gypsum product.

(*c*) Plymouth Gypsum Co., Fort Dodge, Iowa, produce "Plymouth Rock Stucco," use not given, but probably for *exterior* work; which is a calcined gypsum product.

(*d*) The Associated Metal Lath Manufacturers have defined "stucco" as referring solely to a covering of an exterior wall without regard to the composition of the material.

(*e*) Monument Plaster Co., Harrison, N. J., produce "Oriental Stucco," a material for exterior finish only. This is a lime product.

(*f*) The Association of American Portland Cement Manufacturers have prepared Bulletin No. 22 on Portland-Cement Stucco. In this Bulletin "stucco" is used to mean a covering of an exterior wall only.

4. An examination of other literature in which the word "stucco" is used shows the following:

(*a*) Mr. Edwin C. Eckel, C.E., in his book on "Cements, Limes and Plasters" considers "stucco" as a synonym for Plaster of Paris without definition as to its use in exterior or interior work.

(*b*) Many books describing exterior treatments for buildings by applying coatings of cementitious materials, use the word "stucco" in describing the materials.

(*c*) The paint manufacturers that produce materials for coloring, dampproofing and weatherproofing stucco use the word "stucco" to mean the material used to coat an exterior wall.

(*d*) Among architects, building contractors, and building owners, the word "stucco" has grown to mean an exterior wall covering or coating.

5. Consequently, it is advisable to discontinue the use of the word "stucco" to describe a covering material for an interior surface; since, where the greatest study of the materials for exterior surface covering has been made, "stucco" has been used to differentiate this use of material from all others.

(*B*) PLASTER.

Plaster.

6. The word "plaster" is derived from the Greek and Latin words meaning "to daub on" or "to stuff in."

7. Webster's Unabridged Dictionary defines "plaster" as "a composition of lime, water and sand with or without hair as a bond, for coating walls, ceilings and partitions of houses;" also as "calcined gypsum or plaster of Paris, especially when ground, as used for making ornaments, figures, moldings, etc."

8. For many years, plasters have been divided into two classes, interior and exterior plasters, depending upon the location or exposure of the surface to which the material is applied. Exterior plaster is better defined as "stucco" and should be so called. As a result, the above distinction is not necessary and by elimination, "plaster" means but one thing, namely: a coating for interior surface not exposed to weather.

9. Objection to this limitation in the definition of plaster will perhaps be made by those who use the term "exterior plaster" rather than stucco and the few using "stucco" to mean a special form of material for interior work.

10. It will be noted that the definition of "plaster" proposed in Part II, Section 4 (*a*), does not include uses of the material not given in either the root of the word or in its dictionary definition. The proposed definition merely limits the meaning of the word in order to make it a foundation on which can be built a collection of terms that will accurately describe the many various materials and mixtures used in plastering.

11. This restricted use of the word "plaster" will prevent the present confusion between plasters and the materials used in making plaster, and make clear at once the designed use of the material. Evidence of this confusion is found in the expression "Plaster of Paris," which to many has meant "plaster." The preceding definitions have shown that this material is not plaster, but rather is "calcined gypsum," which it should be called. Other confusing expressions are "stucco wall plaster," and "stucco plaster," which have been used in the past without regard to the location of the use of the material, and mean either interior or exterior wall covering material depending only upon the connection in which they are used or the nature of the product produced by the manufacturer marketing the materials. All these and similar misunderstandings are obviated by using the suggested definitions for "plaster" and "stucco."

(*C*) MORTAR.

12. The word "mortar" is derived from the Latin word "mortarium," meaning a vessel in which substances are pounded or rubbed, and later the pounded or rubbed substances. **Mortar.**

13. Webster's Unabridged Dictionary defines the word as "a building material made by mixing lime, cement or plaster of Paris with sand, water and sometimes other materials; used in masonry for joining stones, bricks, etc., also for plastering and in other ways." From this it appears that "mortar" means the same as that given in preceding paragraphs for stucco, plaster, and mortar.

14. The use of the word "mortar" as given in Part II, Section 5 (*a*), adds no new meaning, but restricts it to a particular use, rendering unnecessary such expressions as "stucco mortar,"

"plaster mortar," etc. It will also remove the confusion resulting from using the same expression to define materials used in making stuccoes, plasters and mortars.

(*D*) PLASTERS AND PLASTERING MATERIALS.

Plasters and Plastering Materials.

15. A careful distinction should be made between plaster and the materials used to make plaster. For instance, hydrated lime may or may not be mixed with sand or other aggregates and a binder to make plaster. In this case, if the plaster is used for scratch or brown coat work, no one individual material is plaster, but the completed mixture is plaster. It is obvious that the aggregate or fiber, even when water is added, does not constitute plaster; consequently the hydrated lime in this case is not justly considered plaster, as it is a part of the mixture in the same manner that the aggregate and binder are parts of the mixture. However, in finishing coat work, if calcined gypsum is not added to gage the mixture, the hydrated lime is plaster.

16. The statements in Section 15 are not contradictory when the definition for "plaster" in Part II, Section 4 (*a*), is carefully considered. Also, this distinction will cause no confusion in practice, as hydrated lime, or even calcined gypsum, is seldom used alone in finishing coat work, the two materials being mixed together to make finishing coat plaster.

17. An examination of literature descriptive of this class of plaster shows a confusing variety of different expressions, all of which are used in naming the same materials used for the same purpose. Some of these terms and the producers using them are as follows:

Cement Plaster is used by:

Plaster Manufacturers' Assoc.
U. S. Gypsum Co.
Michigan Gypsum Co.
Overland Gypsum Co.
American Gypsum Co.
Southern Gypsum Co.
Atlas Wall Plaster Co.
Texas Cement Co.
Arden Plaster Co.
Crown Gypsum Co.
Plymouth Gypsum Co.
Manitoba Gypsum Co.
American Cement Plaster Co.
Rock Plaster Mfg. Co.
J. B. King and Co.
The Alabastine Co.
Acme Cement Plaster Co.
Wotherspoon Plaster Mills, Inc.

18. From this list, which is only representative, it is evident that in the central and western parts of this country "cement plaster" is very generally used to mean "gypsum plaster." Without doubt, many people must think that "gypsum or calcined gypsum" means the same as "cement." This understanding must cause much confusion, as there are a large number of people who consider cement to mean Portland, Rosendale, Keene's, etc., cement.

19. The suggested use of the terms "gypsum plaster" (Part VIII, Section 22 (*c*) *1*) and "cement" (Part XIV, Glossary, Section7) will prevent many misunderstandings.

20. *Hard Wall Plaster*, *Rock Wall Plaster*, *Patent Plaster*, *Calcined Plaster*, *Wall Plaster*, *Stucco Wall Plaster*, etc., are some of the expressions used to mean the material that has been defined as "gypsum plaster." These expressions have not been as generally used as "cement plaster," and of themselves may not have produced misunderstandings, since, with the exception of "stucco wall plaster," they have not been construed to mean other materials than "gypsum plaster." The expression "gypsum plaster" has an advantage over all these terms in that it denotes the particular cementitious material that is used in causing the plaster to harden.

AMERICAN SOCIETY FOR TESTING MATERIALS
PHILADELPHIA, PA., U. S. A.
AFFILIATED WITH THE
INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE SPECIFICATIONS
FOR
FOOTS PERMISSIBLE IN PROPERLY CLARIFIED PURE RAW LINSEED OIL FROM NORTH AMERICAN SEED.[1]

Serial Designation: D 51 – 18 T.

These specifications are issued under the fixed designation D 51; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1918.

I. PERCENTAGE OF FOOTS.

Percentage of Foots.

1. The amount of foots in properly clarified pure raw linseed oil from North American seed, as determined by the test specified below, shall not exceed 2 per cent by volume.

II. METHOD OF DETERMINATION.

Reagents Required.

2. The following reagents are required:

(*a*) Acetone that will pass United States Pharmacopœia specifications.

(*b*) Acid $CaCl_2$ solution, made by saturating with $CaCl_2$ a mixture of 90 parts water and 10 parts concentrated HCl, sp. gr. 1.2, at room temperature.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1921, to Mr. R. L. Hallett, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 129 York St., Brooklyn, N. Y.

3. With all materials at a temperature between 70 and 80° F., mix by shaking in a stoppered flask for exactly one minute, 25 cc. of the well-shaken sample of oil, 25 cc. of acetone and 10 cc. of the acid $CaCl_2$ solution. Transfer the mixture to a burrette where settling can take place for 24 hours. The temperature during this period should be between 70 and 80° F. **Operation.**

The volume of the strata lying between the clear calcium-chloride solution and the clear acetone and oil mixture is read in tenths of a cubic centimeter or a fraction thereof. This reading multiplied by four expresses the amount of foots present as percentage by volume of the oil taken.

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INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE SPECIFICATIONS
FOR
TURPENTINE.[1]

Serial Designation: D 13 - 20 T.

These specifications are issued under the fixed designation D 13; the final number indicates the year of original adoption as standard, or in the case of revision, the year of last revision.

ISSUED, 1920.

Material Covered.

1. These specifications apply both to the turpentine that is distilled from pine oleoresins, commonly known as "gum spirits" or "spirits of turpentine," and to turpentine commonly known as "wood turpentine," which is obtained from resinous wood, whether by steam or by destructive distillation. When ordering under these specifications, the purchaser shall specify whether (*a*) gum spirits or (*b*) wood turpentine is desired. When wood turpentine is specified, it may be stated whether steam or destructively distilled wood turpentine shall be furnished.

I. PROPERTIES AND TESTS

2. Turpentine shall be pure and conform to the following requirements:

Appearance.

3. The turpentine shall be clear and free from suspended matter and water.

Color.

4. The color shall be "Standard" or better.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1921, to Mr. R. L. Hallett, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 129 York St., Brooklyn, N. Y.

These specifications, when adopted as standard, will supersede the present Standard Specifications for Turpentine (Serial Designation: D 13 - 15), 1918 Book of A.S.T.M. Standards.

Odor.

5. The odor shall be characteristic of the variety of turpentine specified and, if desired, shall conform to the odor of the sample agreed upon.

Other Properties.

6. Other properties shall be as follows:

	Maximum.	Minimum.
Specific gravity, 15.5/15°.5 C.	0.875	0.862
Refractive index at 20° C.	1.478	1.468
Residue after polymerization with 38 *N* H_2SO_4:		
Gum spirits—		
Volume, per cent	2.0	.....
Refractive index at 20° C.	.....	1.500
Wood turpentine—		
Volume, per cent	2.5	.....
Refractive index at 20° C.	.....	1.495
Initial boiling point at 760 mm. pressure	160° C.	150° C.
Distilling below 170° C. at 760 mm. pressure, per cent	.....	90

II. DETECTION AND REMOVAL OF SEPARATED WATER.

7. Draw a portion by means of a glass or metal container with a removable stopper or top, or with a "thief," from the lowest part of the container, or by opening the bottom valve of the perfectly level tank car. If water is found to be present, draw it all out, record the quantity, and deduct it from the total volume of liquid delivered.

III. SAMPLING.

8. The method of sampling given under (*a*) shall be used whenever feasible. When method (*a*) is not applicable, method (*b*), (*c*), or (*d*) shall be used according to the special conditions that obtain.

(*a*) *While Loading Tank Car or While Filling Containers for Shipment.*—Samples shall be drawn by the purchaser's inspector at the discharge pipe where it enters the receiving vessel or vessels. The composite sample shall be not less than 5 gal. and shall consist of small portions of not more than 1 qt. each taken at regular intervals during the entire period of loading or filling.

The composite sample thus obtained shall be thoroughly mixed and from it three samples of not less than 1 qt. each shall be placed in clean, dry, glass bottles or tin cans, which shall be nearly filled with the sample and securely stoppered with new, clean corks or well-fitting covers or caps. These shall be sealed and distinctly labeled by the inspector; one shall be delivered to the purchaser, one to the seller, and the third held for check in case of dispute.

(*b*) *From Loaded Tank Car or Other Large Vessel.*—The composite sample taken shall be not less than 5 gal. and shall consist of numerous small samples of not more than 1 qt. each taken from the top, bottom, and intermediate points by means of a metal or glass container with removable stopper or top. This device, attached to a suitable pole, is lowered to the various desired depths, when the stopper or top is removed and the container allowed to fill. The sample thus obtained is handled as in method (*a*).

(*c*) *Barrels and Drums.*—Barrels and drums shall be sampled after gaging contents. Five per cent of the packages in any shipment or delivery shall be represented in the sample. Thoroughly mix the contents of each barrel to be sampled by stirring with a clean rod and withdraw a portion from about the center by means of a "thief" or other sampling device. The composite sample thus obtained shall be not less than 3 quarts, shall consist of equal portions of not less than ½ pt. from each package sampled, and shall be handled as in method (*a*). Should the inspector suspect adulteration, he shall draw the samples from the suspected packages.

(*d*) *Small Containers, Cans, etc., of 10 Gal. or Less.*—These shall be sampled, while filling, by method (*a*) whenever possible; but in case this is impossible the composite sample taken shall be not less than 3 qt. This shall be drawn from at least five packages (from all when fewer), and in no case from less than 2 per cent of the packages. The composite sample thus taken shall be thoroughly mixed and subdivided as in method (*a*).

IV. LABORATORY EXAMINATION.

9. Samples will, in general, be tested by the following methods; but the purchaser reserves the right to apply any additional tests or use any available information to ascertain whether the material meets the specifications.

Appearance. 10. Examine to determine compliance with the specifications.

Color. 11. Fill a 200-mm. perfectly flat-bottomed colorimeter tube, graduated in millimeters, to a depth of from 40 to 50 mm. with the turpentine to be examined. Place the tube in a colorimeter and place on or under it a No. 2 yellow Lovibond glass. Over or under a second graduated tube in the colorimeter, place a No. 1 yellow Lovibond glass and run in the same turpentine until the color matches as nearly as possible the color in the first tube. Read the difference in depth of the turpentine in the two tubes. If this difference is 50 mm. or more, the turpentine is "Standard" or better.

Odor.

12. Determine odor by comparison with several samples of known purity, which have been kept in the dark in completely filled, well-stoppered bottles and are free from separated water.

Specific Gravity.

13. Determine specific gravity at 15.5/15°.5 C., in a pyknometer accurately standardized and having a capacity of at least 25 cc.; or by any other equally accurate method.

Refractive Index.

14. Determine refractive index at 20° C. with an accurate instrument. When the refractive index is determined at any other temperature, the readings obtained shall be corrected to 20° C. by adding to or by subtracting from the actual reading 0.00045 for each degree Centigrade that the temperature at which the determination was made is, respectively, above or below 20° C.

Distillation.

15. *Apparatus.*—(*a*) *Condenser.*—The type of apparatus (see Fig. 1) adopted in the Standard Tests for Paint Thinners other than Turpentine (Serial Designation: D 28) of the American Society for Testing Materials,[1] substituting for the thermometer there described an immersed thermometer such as is described below, is preferred. In case the A. S. T. M. distillation apparatus is not available, use an ordinary straight glass-tube condenser, about 22 in. long, with 16 in. in contact with the cooling water. The end of the condenser tube should be fitted with an adapter or should be bent down to a nearly vertical position, and the tip should be cut off or ground down at an acute angle. The tip should extend a short distance into the receiving cylinder.

(*b*) *Flask.*—Comparable results can be obtained only by using flasks of the same dimensions. The distilling flask used shall be the standard Engler flask, as used for petroleum distillation, having the following dimensions: Diameter of bulb, 6.5

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[1] 1918 Book of A.S.T.M. Standards.

cm.; cylindrical neck, 15 cm. long, 1.6 cm. internal diameter; side or vapor tube, 10 cm. long, 0.6 cm. external diameter; attached to neck at an angle of 75 deg., so that when the flask contains its charge of 100 cc. of oil the surface of the liquid shall be 9 cm. below the bottom of the junction of the side tube and neck.

(*c*) *Support for Flask.*—Support the flask on a plate of asbestos 20 cm. in diameter, having an opening 4 cm. in diameter in its center, and heat with an open flame. Surround the flask and burner with a shield to prevent fluctuation in the temperature of the neck of the flask. Or, support the flask in a metal cup, 15 to 20 cm. in diameter, containing high-boiling mineral oil or glycerin and fitted with a concave cover having in the center a circular opening 5½ to 6 cm. in diameter. In all cases take the

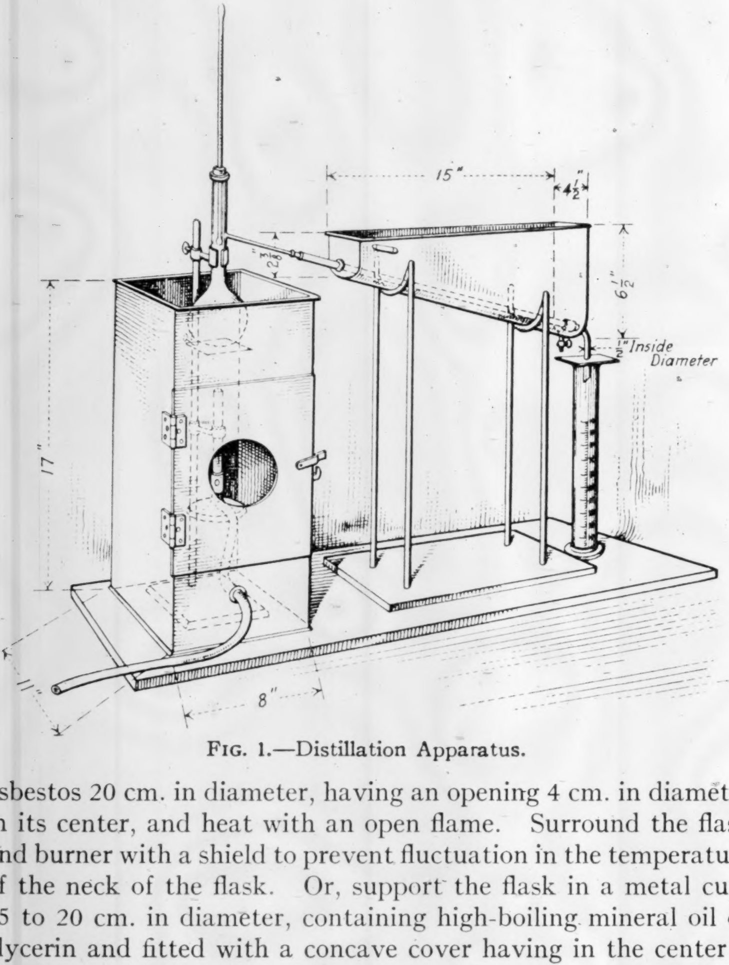

FIG. 1.—Distillation Apparatus.

necessary precautions to prevent fluctuation in temperature in the neck of the flask.

(*d*) *Thermometer.*—The thermometer used for turpentine distillation shall conform to the following specifications:

It shall be graduated from 145° to at least 200° C. in 0°.2 intervals. Length, bottom of thermometer to 175° mark, not more than 8 nor less than 6.5 cm. Length, top of bulb to 145° mark, not less than 1.5 cm. Length, 145 to 175° mark, not more than 6 cm. Thermometers graduated above 200° C. may be used, provided they also comply with the foregoing requirements.

The thermometer shall be made of suitable thermometric glass and thoroughly annealed, so that the scale errors will not increase after continued heating.

The thermometer shall be filled above the mercury with an inert gas, with sufficient pressure above the mercury column to prevent breaking of the column. It shall have a reservoir at the top, so that the pressure will not become excessive at the highest temperature.

Every fifth graduation shall be longer than the intermediate ones, and the marks shall be numbered at each interval of 5°. The graduation marks shall be clear-cut and fine and the numbering clear-cut and distinct.

The error at any point on the scale shall not exceed ±0°.5 C. when tested for total immersion of the mercury column.

(*e*) *Receiving Cylinder.*—Collect the distillate in an accurately graduated 50 or 100-cc. cylinder. The so-called normal or precision cylinder of 50 cc. capacity, having an internal diameter of 1.5 cm. and graduated in 0.2 cc., is preferred. If a cylinder with larger inside diameter is used, a pasteboard cover should be placed over the top and surround the condenser tube.

16. *Operation.*—Place 100 cc. of the turpentine and several small pieces of pumice (or glass) in the distilling flask, fit the thermometer so that the top of the mercury bulb is level with the bottom of the side tube, and the 175° C. mark is below the cork. Place the flask in position on the asbestos board or oil bath and connect with the condenser. Apply the heat cautiously at first, and, when distillation begins, regulate the heat so that the turpentine distills at the rate of not less than

4 nor more than 5 cc. per minute (appromixately two drops per second). The initial boiling point is the thermometer reading at the instant when the first drop falls from the end of the condenser. Discontinue distillation when the temperature reaches 170° C., or an equivalent thereof, depending on the atmospheric pressure, as described in Section 17; let the condenser drain and read the percentage distilled.

The percentage distilled below successive selected temperatures and the temperature at which each successive 10 cc. distills may also be determined, if desired, making the necessary correction of the temperature for variations in atmospheric pressure.

17. *Correction for Variation in Atmospheric Pressure.*—Since distillation results are comparable only when obtained under exactly the same pressure conditions, turpentine shall be distilled at that pressure which, at room temperature, is equivalent to a pressure of 760 mm. of mercury at 0° C. Whenever the atmospheric pressure after correcting to 0° C. is other than 760 mm., a correction shall be made. Since alteration of the pressure in the distilling system requires rather complicated apparatus, it is simpler to alter the temperature observation points to correspond to the prevailing pressure.

To determine what the atmospheric pressure at the prevailing room temperature, or at the temperature of the barometer, would be at 0° C., read the barometer and the thermometer alongside when about to begin distillation. Refer to Table I. Under the column nearest the observed pressure reading, and on the line nearest the observed temperature of the barometer will be found the correction which must be subtracted from the observed pressure reading to obtain the equivalent, or true, reading at 0° C.

The distilling temperature of turpentine is affected plus (+) or minus (−) 0°.057 C. for each millimeter variation of the barometer above or below the normal 760 mm. at 0° C.[1] If the barometer reading, after correcting to 0° C., is below 760 mm., the turpentine will distill at a slightly lower temperature than under normal pressure. Therefore, the temperature recorded at the beginning of distillation (and any others observed during the course of the distillation) must be corrected to get its equivalent at normal pressure. The final temperature observation point (170° C., Section 16) must be altered accordingly to get its equivalent at the pressure (corrected to 0° C.) at which distillation is made.

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[1] Landolt-Börnstein Physikalisch-Chemische Tabellen, Ed. 4, Table 127, p. 435

For example, if the barometer reading, after correcting to 0° C., is 750 mm., the correction of the observed initial distilling temperature will be $0.057 \times 10 = 0^\circ.6$ C. approximately. If the reading of the thermometer when the turpentine begins to distill is 155°.6 C., the corrected initial distilling temperature will be $155^\circ.6 + 0^\circ.6 = 156^\circ.2$ C. Furthermore, the temperature observation point at end of distillation (170° C. at 760 mm.) must be altered to the same extent. Since the turpentine is distilling 0°.6 C. below what it would at normal pressure, distillation must be discontinued at 0°.6 C. below the specified limit of 170° C. to determine the percentage distilling below 170° C.

TABLE I.—CORRECTION TO BAROMETER READINGS.[1]

(From Circular F, Instrument Division, Weather Bureau, U. S. Department of Agriculture.)

Temperature, deg. Cent.	Observed Reading of Barometer, mm.														
	640	650	660	670	680	690	700	710	720	730	740	750	760	770	780
15.0	1.56	1.59	1.61	1.64	1.66	1.69	1.71	1.74	1.76	1.78	1.81	1.83	1.86	1.88	1.91
16.0	1.67	1.69	1.72	1.75	1.77	1.80	1.83	1.85	1.88	1.90	1.93	1.96	1.98	2.01	2.03
17.0	1.77	1.80	1.83	1.86	1.88	1.91	1.94	1.97	1.99	2.02	2.05	2.08	2.10	2.13	2.16
18.0	1.88	1.91	1.93	1.96	1.99	2.02	2.05	2.08	2.11	2.14	2.17	2.20	2.23	2.26	2.29
19.0	1.98	2.01	2.04	2.07	2.10	2.13	2.17	2.20	2.23	2.26	2.29	2.32	2.35	2.38	2.41
20.0	2.08	2.12	2.15	2.18	2.21	2.25	2.28	2.31	2.34	2.38	2.41	2.44	2.47	2.51	2.54
21.0	2.19	2.22	2.26	2.29	2.32	2.36	2.39	2.43	2.46	2.50	2.53	2.56	2.60	2.63	2.67
22.0	2.29	2.33	2.36	2.40	2.43	2.47	2.51	2.54	2.58	2.61	2.65	2.69	2.72	2.76	2.79
23.0	2.40	2.43	2.47	2.51	2.54	2.58	2.62	2.66	2.69	2.73	2.77	2.81	2.84	2.88	2.92
24.0	2.50	2.54	2.58	2.62	2.66	2.69	2.73	2.77	2.81	2.85	2.89	2.93	2.97	3.01	3.05
25.0	2.60	2.64	2.68	2.72	2.77	2.81	2.85	2.89	2.93	2.97	3.01	3.05	3.09	3.13	3.17
26.0	2.71	2.75	2.79	2.83	2.88	2.92	2.96	3.00	3.04	3.09	3.13	3.17	3.21	3.26	3.30
27.0	2.81	2.85	2.90	2.94	2.99	3.03	3.07	3.12	3.16	3.20	3.25	3.29	3.34	3.38	3.42
28.0	2.91	2.96	3.00	3.05	3.10	3.14	3.19	3.23	3.28	3.32	3.37	3.41	3.46	3.51	3.55
29.0	3.02	3.06	3.11	3.16	3.21	3.25	3.30	3.35	3.39	3.44	3.49	3.54	3.58	3.63	3.68
30.0	3.12	3.17	3.22	3.27	3.32	3.36	3.41	3.46	3.51	3.56	3.61	3.66	3.71	3.75	3.80
31.0	3.22	3.27	3.32	3.37	3.43	3.48	3.53	3.58	3.63	3.68	3.73	3.78	3.83	3.88	3.93
32.0	3.33	3.38	3.43	3.48	3.54	3.59	3.64	3.69	3.74	3.79	3.85	3.90	3.95	4.00	4.05
33.0	3.43	3.48	3.54	3.59	3.64	3.70	3.75	3.81	3.86	3.91	3.97	4.02	4.07	4.13	4.18

[1] These corrections apply to a mercurial barometer with brass scale. They can, however, be used for a mercurial barometer with glass scale, since the errors introduced thereby are negligible as applied to the work contemplated in this circular. For exact correction to be applied to such a barometer see Smithsonian Physical Tables, p. 119 (1914). An aneroid barometer should not be relied on.

For barometer readings below 640 mm. the correction can be interpolated, since the difference, at any particular temperature for each 10 mm. variation in barometer reading is practically constant.

If the barometer reading corrected to 0° C. is above 760 mm., subtract the temperature correction from the observed thermometer reading to determine the initial distilling point, and continue distillation to 170° C. plus the correction to determine the percentage distilling below 170° C.

Polymerization

18. (*a*) Place 20 cc. of 38 *N* (equivalent to 100.92 per cent H_2SO_4) sulfuric acid in a graduated, narrow-necked Babcock flask, stopper, and place in ice water to cool. Add slowly, from a pipette, 5 cc. of the turpentine to be examined. Gradually mix the contents, keeping warm, but being very careful that the temperature does not rise above 60° C. When the mixture no longer warms up on shaking, agitate thoroughly and place the flask in a water bath and heat at 60 to 65° C. for not less than 10 minutes, keeping the contents of the flask thoroughly mixed by vigorous shaking for one-half minute each time, six times during the period. Do not stopper the flask after the turpentine has been added, as it may explode. Cool to room temperature, fill the flask with concentrated sulfuric acid until the unpolymerized oil rises into the graduated neck and centrifuge from four to five minutes at not less than 1200 r. p. m., or for 15 minutes at 900 r. p. m., or allow to stand, lightly stoppered, for 12 hours. Calculate the percentage, note the consistency and color, and determine the refractive index (at 20° C.) of the unpolymerized residue. The consistency should be viscous and the color straw or darker.

(*b*) *Reagent for Testing.*—In a weighed glass-stoppered bottle (the regular 2½-liter acid bottle is of a convenient size) mix ordinary concentrated sulfuric acid (sp. gr. 1.84) with fuming sulfuric acid. If the fuming acid used contains 50 per cent excess SO_3, the ratio of one part, by weight, of the former to three-fourths of a part, by weight, of the latter will give a mixture slightly stronger than the required strength. To determine the exact strength of this mixture in terms of H_2SO_4, weigh exactly, in a weighing pipette of about 10 cc. capacity, approximately 20 g. of the acid. Allow it to flow down the sides of the neck into a 1000-cc. volumetric flask containing about 200 cc. of distilled water. When the pipette has drained, wash all traces of the acid remaining in the pipette into the flask, taking precautions to prevent loss of SO_3, and make up to the mark. Titrate 20-cc. portions, drawn from a burette, against half normal alkali. Calculate the concentration in terms of the percentage of H_2SO_4 in the sample taken.

In the same way determine the percentage of H_2SO_4 in the stock of ordinary concentrated acid (sp. gr. 1.84). From these data calculate the quantity of the latter which must be added to the quantity of mixed acid in the weighed bottle to bring it to a concentration, in terms of H_2SO_4, of 100.92 per cent.

After adjusting the concentration by the addition of the ordinary sulfuric acid, thoroughly shake the bottle of mixed acid and again determine its concentration. The allowable variation is ±0.05 per cent H_2SO_4. Finally as a check run a polymerization test on gum turpentine known to be pure. The residue should fall below 2 per cent.

Special precautions must be taken to prevent dilution of this acid by the absorption of atmospheric moisture. The arrangement shown in Fig. 2 is most suitable for storing and delivering measured quantities of this reagent.

With the three-way stopcocks *A* and *B* in the position shown, acid is siphoned into the pipette *P*, the displaced air passing into *R*. To empty the pipette, *A* and *B* are turned to the position shown by the broken lines, air passing in at *a*. The acid adhering to the walls of the pipette dries this air so that when it passes into *R* on again filling the pipette there is no accumulation of moisture in the acid remaining in the reservoir. If such arrangement is not to be had, the acid should be kept in well-fitting glass-stoppered bottles of not more than one-half liter capacity.

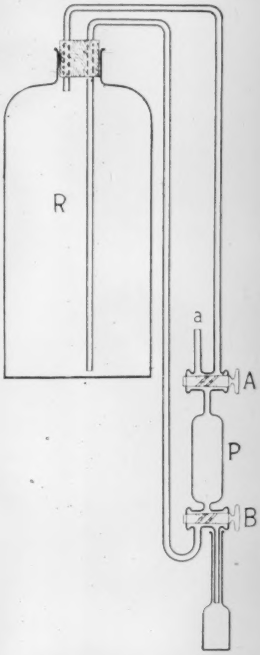

FIG. 2.—Acid Bottle and Pipette.

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TENTATIVE SPECIFICATIONS
FOR
BLOCK FOR GRANITE BLOCK PAVEMENTS.[1]

Serial Designation: D 59 – 19 T.

These specifications are issued under the fixed designation D 59; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1919.

General. 1. The blocks shall be of granite of medium-size grain, showing an even distribution of constituent minerals. They shall be of uniform quality and texture throughout, and free from seams or disintegrated materials.

I. PHYSICAL PROPERTIES AND TESTS.

Physical Properties. 2. The average of three tests on sample blocks shall conform to the following requirements as to physical properties:

FOR HEAVY TRAFFIC.

French coefficient of wear	not less than	11
Toughness	" " "	9

FOR MODERATELY HEAVY TRAFFIC.

French coefficient of wear	not less than	8
Toughness	" " "	7

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1921, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third Street, New York City.

Methods of Testing.

3. (*a*) The French coefficient of wear shall be determined in accordance with the Standard Test for Abrasion of Road Material (Serial Designation: D 2) of the American Society for Testing Materials.[1]

(*b*) The toughness shall be determined in accordance with the Standard Test for Toughness of Rock (Serial Designation: D 3) of the American Society for Testing Materials.[1]

II. DIMENSIONS.

Dimensions.

4. The blocks shall conform to the following requirements as to dimensions:

Length on top, in.	8 to 12
Width on top, in.	$3\frac{1}{2}$ to $4\frac{1}{2}$
Depth, in.	$4\frac{3}{4}$ to $5\frac{1}{4}$

III. DRESSING.

Dressing.

5. (*a*) The blocks shall be so dressed that the faces will be approximately rectangular in shape, and the ends and sides sufficiently smooth to permit the blocks to be laid with joints not exceeding $\frac{1}{2}$ in. in width at the top, and for 1 in. downward therefrom, and not exceeding 1 in. in width at any other part of the joint.

(*b*) The wearing surface of the blocks shall show no depressions more than $\frac{3}{8}$ in. deep, and the edges and corners shall be unchipped and unbroken.

IV. INSPECTION.

Inspection.

6. (*a*) At least six blocks shall be selected for physical tests by the engineer or his authorized representative, subsequent to delivery at the place of use, so as to fairly represent actual deliveries. No sample shall include blocks that would be rejected by a visual examination. The bedding plane shall be marked on at least two of the blocks selected.

(*b*) All deliveries shall be subjected to further inspection at the place of use, prior to and during laying. All blocks which fail to conform to the requirements of Sections 1, 5 and 6 shall be rejected.

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[1] 1918 Book of A.S.T.M. Standards.

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TENTATIVE SPECIFICATIONS FOR WORKABILITY OF CONCRETE FOR CONCRETE PAVEMENTS.[1]

Serial Designation: D 62 – 20 T.

These specifications are issued under the fixed designation D 62; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1920.

1. The workability[2] of concrete for concrete pavements shall be as follows:

Machine Finishing. (*a*) For concrete to be finished by mechanical tamping machine, the slump shall be not more than 1 in.

Hand Finishing. (*b*) For concrete to be finished by hand methods, the slump shall be not more than $1\frac{1}{2}$ in.

Determination of Workability. 2. In determining workability, the newly mixed concrete shall be placed in a truncated cone-shaped metal mold 12 in. high, 8 in. in diameter at the base, and 4 in. in diameter at the top, and provided with handles at the sides. The concrete shall be lightly tamped with a rod as it is placed in the mold which, when filled, shall be immediately removed and the slump or settlement of the concrete noted.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1921, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third Street, New York City.

[2] The desired workability is to be obtained by varying the water content.

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TENTATIVE SPECIFICATIONS
FOR
COMMERCIAL SIZES OF BROKEN STONE AND BROKEN SLAG FOR HIGHWAY CONSTRUCTION.[1]

Serial Designation: D 63 – 20 T.

These specifications are issued under the fixed designation D 63; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1920.

Material Covered.

1. These specifications cover the standard size designations and maximum permissible range in mechanical analyses for nine commercial grades of broken stone and broken slag, when used in the construction of plain or bituminous macadam, bituminous concrete, sheet asphalt and cement-concrete roads and pavements.

I. MANUFACTURE.

Screening Process.

2. The standard sizes herein specified may be produced from the run of the crusher by means of any screening process in which the factors influencing the efficiency of the screening operation are so adjusted that the designated sizes will conform to the requirements for mechanical analysis specified in Section 4.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1921, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third St., New York City.

II. STANDARD SIZES.

Standard Sizes.

3. Each of the standard sizes shall be designated by reference to both the upper and lower nominal limiting size of the product: thus, "$\frac{1}{4}$ to $\frac{3}{4}$-in. size" indicating that portion of the product of a crusher, all of which is nominally between $\frac{1}{4}$ and $\frac{3}{4}$ in. in size.

III. PERMISSIBLE VARIATIONS IN MECHANICAL ANALYSIS.

Permissible Variations in Mechanical Analysis.

4. The designated size for each grade together with the corresponding maximum permissible variations in mechanical analyses as determined by the use of laboratory screens, are given in the following table:

MAXIMUM PERMISSIBLE RANGE IN MECHANICAL ANALYSIS FOR EACH SIZE

PERCENTAGE BY WEIGHT PASSING LABORATORY SCREENS.

Designated Size, in.	Diameter of Screen Openings, in.						
	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{3}{4}$	1	$1\frac{1}{4}$	$2\frac{1}{2}$	$3\frac{1}{2}$
0 - $\frac{1}{4}$	85–100	......	......	......	......	......	......
0 - $\frac{1}{2}$	0– 75	95–100	......	......	......	......	......
0 - $\frac{3}{4}$	40– 80	......	95–100	......	......	......	......
$\frac{1}{4}$ - $\frac{3}{4}$	0– 15	25– 75	95–100	......	......	......	......
$\frac{1}{4}$ - $1\frac{1}{4}$	3– 10	......	65– 85	......	95–100	......	......
$\frac{1}{4}$ - $2\frac{1}{2}$	0– 5	......	......	......	25– 75	95–100	......
$\frac{3}{4}$ - $1\frac{1}{4}$	......	......	0– 15	25– 75	95–100	......	......
$1\frac{1}{4}$ - $2\frac{1}{2}$	......	......	......	......	0– 15	95–100	......
$2\frac{1}{2}$ - $3\frac{1}{2}$[a]	......	......	......	......	......	0– 15	95–100

[a] In the case of light or porous slags a 4-in. maximum size may be specified instead of $3\frac{1}{2}$ in.

IV. SIZE OF SAMPLES.

Samples.

5. Samples of broken stone or broken slag which are to be examined to determine conformity with these specifications shall weigh at least 50 times the weight of the largest piece therein and be strictly representative of the product sampled.

EXPLANATORY STATEMENT.

The commercial sizes designated in the accompanying proposed specifications provide primarily for the separation of the run of crusher into five sizes not including the 0-$\frac{1}{2}$-in. size.

Although the limiting sizes were determined after carefully considering the size requirements of the various types of roads using broken stone or slag, no definite requirements regarding use have been inserted, as such requirements will be included in specifications which are to be prepared by Committee D-4. It will be noted that a general tolerance of 15 per cent on the lower limiting size and 5 per cent on the upper limiting size for each grade is specified. It is felt that this will cover all unavoidable variations in grading of a given designated product. An intermediate size requirement of from 25 to 75 per cent is also given for the $\frac{1}{4}$ to $\frac{3}{4}$-in. and the $\frac{3}{4}$ to $1\frac{1}{4}$-in. sizes. It is felt that for the two larger sizes an intermediate size requirement is not necessary. For the combination sizes which will ordinarily be used in cement-concrete work, a lower tolerance of 5 per cent is specified. In Table I various uses to which the different grades are adapted are indicated.

TABLE I.—VARIOUS USES FOR WHICH THE DIFFERENT GRADES OF STONE ARE ADAPTED.

Designated Size, in.	Suggested Uses.
0 – $\frac{1}{4}$.....	For fine screenings for waterbound macadam.
0 – $\frac{1}{2}$.....	" fine aggregate for bituminous concrete.
$\frac{1}{4}$ – $\frac{3}{4}$.....	" dustless screenings or chips for bituminous macadam or bituminous surface treatment.
$\frac{3}{4}$ – $1\frac{1}{4}$.....	" coarse chips or 1-in. stone for bituminous macadam.
$1\frac{1}{4}$ – $2\frac{1}{2}$.....	" wearing course, waterbound macadam or bituminous macadam
$2\frac{1}{2}$ – $3\frac{1}{2}$.....	" broken-stone base course.
	COMBINATION SIZES.
0 – $\frac{3}{4}$	For coarse screenings for waterbound macadam.
$\frac{1}{4}$ – $1\frac{1}{4}$.....	" aggregate for reinforced concrete, bituminous concrete, sheet asphalt binder course.
$\frac{1}{4}$ – $2\frac{1}{2}$.....	" coarse aggregate for cement-concrete roads and structures.

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TENTATIVE SPECIFICATIONS

FOR

COMMERCIAL SIZES OF SAND AND GRAVEL FOR HIGHWAY CONSTRUCTION.

Serial Designation: D 64 – 20 T.

These specifications are issued under the fixed designation D 64; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1920.

Material Covered.

1. These specifications cover the standard size designations and maximum permissible range in mechanical analyses for nine commercial grades of sand and gravel, when used in the construction of waterbound-gravel and cement-concrete roads and pavements.

I. MANUFACTURE.

Screening Process.

2. The standard sizes herein specified may be produced from any screening process in which the factors influencing the efficiency of the screening operation are so adjusted that the designated sizes will conform to the requirements for mechanical analysis specified in Section 4.

II. STANDARD SIZES.

Standard Sizes.

3. Each of the standard sizes shall be designated by reference to both the upper and lower nominal limiting size of the

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1921, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third Street, New York City.

product: thus, "$\frac{1}{4}$ to $\frac{3}{4}$-in. size" indicating that portion of the product of a sand and gravel screening plant, all of which is nominally between $\frac{1}{4}$ and $\frac{3}{4}$ in. in size.

III. PERMISSIBLE VARIATIONS IN MECHANICAL ANALYSES.

Permissible Variations in Mechanical Analysis.

4. The designated size for each grade together with the corresponding maximum permissible variations in mechanical analyses as determined by the use of laboratory screens and with sieves as specified in the Standard Method for Making a Mechanical Analysis of Sand or Other Fine Highway Material, except Fine Aggregates Used in Cement Concrete (Serial Designation: D 7) of the American Society for Testing Materials,[1] are given in the following table:

MAXIMUM PERMISSIBLE RANGE IN MECHANICAL ANALYSIS FOR EACH SIZE.
PERCENTAGE BY WEIGHT PASSING EACH SCREEN.

Designated Size, in.	Diameter of Screen Openings, in.							
	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{3}{4}$	1	$1\frac{1}{2}$	2	$2\frac{1}{2}$	$3\frac{1}{2}$
0 - $\frac{1}{4}$ [a]	95-100	......	......	......	......	......	......	......
0 - $\frac{1}{4}$ [b]	85-100	......	......	......	......	......	......	......
$\frac{1}{4}$ - $\frac{1}{2}$	c	95-100	......	......	......	......	......	......
$\frac{1}{4}$ - $\frac{3}{4}$	c	......	95-100	......	......	......	......	......
$\frac{1}{4}$ - 1	c	25- 75	......	95-100	......	......	......	......
$\frac{1}{4}$ - $1\frac{1}{2}$	c	......	25- 75	......	95-100	......	......	......
$\frac{1}{4}$ - 2	c	......	......	25- 75	......	95-100	......	......
$\frac{1}{4}$ - $2\frac{1}{2}$	c	......	......	......	25- 75	......	95-100	......
1 - 2	......	......	......	0- 15	......	85-100	......	......
2 - $3\frac{1}{2}$	......	......	......	......	......	0- 15	......	85-100

[a] Additional requirements for grading shall be as follows:

Passing 20-mesh sieve	25 to 75 per cent
Passing 50-mesh sieve	not over 25 "
Passing 100-mesh sieve	" " 5 "

[b] Limits for silt and clay content may be inserted if desired.

[c] Any percentage from 0 to 10 per cent may be designated, with a maximum permissible variation therefrom of not more than $2\frac{1}{2}$ per cent.

IV. SIZE OF SAMPLES.

Samples.

5. Samples of sand shall weigh at least 10 lb. Samples of gravel and samples composed of mixtures of sand and gravel shall weigh at least 50 times the weight of the largest piece therein.

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[1] 1918 Book of A.S.T.M. Standards.

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TENTATIVE SPECIFICATIONS
FOR
BROKEN SLAG FOR WATERBOUND BASE.[1]

Serial Designation: D 65 - 20 T.

These specifications are issued under the fixed designation D 65; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1920.

Material Covered.

1. These specifications cover primarily slag screenings and coarse slag to be used in the construction of a waterbound base upon which some higher type of wearing course will be placed, preferably after the base has been firmly compacted by traffic. For a light traffic road it may also serve for both foundation and wearing course, provided the thickness of each is not less than 4 in.

General Characteristics of Slag.

2. The broken slag shall be air-cooled blast-furnace slag and shall consist of angular fragments reasonably uniform in density and quality, and reasonably free from thin, elongated or glassy pieces, dirt or other objectionable matter.

Weight.

3. The weight per cubic foot of each size specified, shall be not less than 65 lb.

Percentage of Wear.

4. The percentage of wear shall be not more than 12.0 per cent.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1921, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third Street, New York City.

Screenings.

5. Screenings are that portion of the product of the crusher, including the dust of fracture, which, when tested by means of laboratory screens, shall meet the following requirements:

Passing ¾-in. screen	not less than 95 per cent
Passing ¼-in. screen	40 – 80 "

Coarse Slag.

6. Coarse slag is that portion of the product of the crusher which, when tested by means of laboratory screens, shall meet the following requirements:

Passing 4-in. screen	not less than 95 per cent
Retained on 2½-in. screen	" " " 85 "

Methods of Testing.

7. (*a*) *Weight per Cubic Foot.*—The weight per cubic foot shall be determined as specified in the Tentative Test for Unit Weight of Aggregate for Cement Concrete (Serial Designation: C 29 – 20 T) of the American Society for Testing Materials.[1]

(*b*) *Percentage of Wear.*—The percentage of wear shall be determined as specified in the Standard Test for Abrasion of Road Materials (Serial Designation: D 2) of the American Society for Testing Materials,[2] using however a volume of 4000 cc. measured loose of the broken slag of the size specified in the standard test.

Sampling.

8. The method of sampling shall conform to the Tentative Methods for Sampling of Stone, Slag, Gravel, Sand and Stone Block for Use as Highway Materials, including Some Material Survey Methods (Serial Designation: D 75 – 20 T) of the American Society for Testing Materials.[3]

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[1] See p. 624.

[2] 1918 Book of A.S.T.M. Standards.

[3] See p. 789.

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TENTATIVE SPECIFICATIONS FOR SHOVEL-RUN OR CRUSHER-RUN BROKEN SLAG FOR WATERBOUND BASE.[1]

Serial Designation: D 66 – 20 T.

These specifications are issued under the fixed designation D 66; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1920.

Material Covered.

1. These specifications cover primarily slag to be used in the construction of a waterbound base upon which some higher type of wearing course will be placed, preferably after the base has been compacted by traffic.

General Characteristics of Slag.

2. The broken slag shall be air-cooled blast-furnace slag and shall consist of angular fragments reasonably uniform in density and quality, and reasonably free from thin, elongated or glassy pieces, dirt or other objectionable matter.

Weight.

3. The weight per cubic foot shall be not less than 65 lb.

Percentage of Wear.

4. The percentage of wear shall be not more than 15.0 per cent.

Grading.

5. Shovel-run or crusher-run slag, when tested by means of laboratory screens, shall meet the following requirements:

Passing 4-in. screen................	not less than 95 per cent
Passing $2\frac{1}{2}$-in. screen......................	25 – 75 "

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1921, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third Street, New York City.

Methods of Testing.

6. (*a*) *Weight per Cubic Foot.*—The weight per cubic foot shall be determined as specified in the Tentative Test for Unit Weight of Aggregate for Cement Concrete (Serial Designation: C 29 – 20 T) of the American Society for Testing Materials.[1]

(*b*) *Percentage of Wear.*—The percentage of wear shall be determined as specified in the Standard Test for Abrasion of Road Materials (Serial Designation: D 2) of the American Society for Testing Materials,[2] using however a volume of 4000 cc. measured loose of the broken slag of the size specified in the standard test.

Sampling.

7. The method of sampling shall conform to the Tentative Methods for Sampling of Stone, Slag, Gravel, Sand and Stone Block for Use as Highway Materials, including Some Material Survey Methods (Serial Designation: D 75 – 20 T) of the American Society for Testing Materials.[3]

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[1] See p. 624.

[2] 1918 Book of A.S.T.M. Standards.

[3] See p. 789.

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TENTATIVE SPECIFICATIONS FOR NATURAL OR ARTIFICIAL SAND-CLAY MIXTURES FOR HIGHWAY SURFACING.[1]

Serial Designation: D 67 - 20 T.

These specifications are issued under the fixed designation D 67; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1920.

Material Covered. 1. These specifications cover sand-clay and mixtures of sand-clay and gravel containing not more than 50 per cent of material over ¼ in. in size, when used in road construction.

Character of Material. 2. The sand-clay shall be composed of either a naturally occurring or artificially prepared mixture of hard, durable, preferably angular, fragments of sand, together with silt and clay with or without gravel, and shall be free from an excess of feldspar or mica.

Grading. 3. (*a*) When tested by means of laboratory sieves and screens the sand-clay or gravel shall meet the following requirements for grading:

Passing 2-in. screen	100 per cent
Passing ¼-in. screen	50 to 100 "

(*b*) The material, if any, retained on a ¼-in. screen shall be uniformly graded from the maximum size present to ¼ in.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1921, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third Street, New York City.

(*c*) The material passing a $\frac{1}{4}$-in. screen shall meet the following requirements:

Total sand	50 to 80 per cent
Sand over 50-mesh[1]	25 " 50 "
Silt	5 " 20 "
Clay	15 " 30 "

Methods of Testing.

4. Tests for the determination of clay and silt shall be made in accordance with the Tentative Test for Quantity of Clay and Silt in Sand for Highway Construction (Serial Designation: D 74 – 20 T) of the American Society for Testing Materials.[2] The test for determination of clay shall be made in accordance with the Tentative Test for Quantity of Clay in Sand-clay, Topsoil, and Semi-Gravel for Highway Construction (Serial Designation: D 73 – 20 T) of the American Society for Testing Materials.[3] The percentage of silt is that obtained by subtracting the percentage of clay from the percentage of clay and silt. Test for the grading of the sand-clay mixtures shall be made in accordance with the Standard Method for Making a Mechanical Analysis of Sand or Other Fine Highway Material except Fine Aggregates Used in Cement Concrete (Serial Designation: D 7) of the American Society for Testing Materials,[4] using, however, the washed sample remaining after the clay and silt determination.

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[1] For specifications for this sieve, see Standard Method for Making a Mechanical Analysis of Sand or Other Fine Highway Material, except Fine Aggregates Used in Cement Concrete (D 7), 1918 Book of A.S.T.M. Standards.

[2] See p. 774.

[3] See p. 772.

[4] 1918 Book of A.S.T.M. Standards.

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TENTATIVE SPECIFICATIONS
FOR
STRUCTURAL DOUGLAS FIR.[1]

Serial Designation: D 23 – 20 T.

These specifications are issued under the fixed designation D 23; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1916; REVISED, 1920.

Material Covered.

1. (*a*) These specifications describe the properties and factors which must be considered in the production of material wherein uniformity in strength, hardness and durability are required.

(*b*) The specifications are divided into two parts:

A. Dense Douglas Fir, describing the method of selecting material for density;

B. Structural Grades, covering the production of structural timbers.

A. DENSE DOUGLAS FIR.

I. DEFINITIONS.

Definitions.

2. The following definitions are used in connection with these specifications:

(*a*) *Annual Ring.*—Each annual ring is composed of two distinct types of wood structure: namely, the porous, light-colored and light-weight spring wood formed during the first part of the growing season and the hard, dense and darker colored summer wood formed during the latter part of the growing season.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1921, to Mr. Herman von Schrenk, Chairman of Committee D-7 on Timber, Tower Grove and Flad Avenue, St. Louis, Mo.

(*b*) *Summer Wood.*—Summer wood is the hard, dense portion of the annual ring. It is darker in color than the more porous spring wood.

(*c*) *Dense Douglas Fir.*—This term is applied to a class of material selected with reference to the density of its wood substance content. It shall be understood that this term is descriptive of the quality of the clear wood.

II. PHYSICAL PROPERTIES.

Rate of Growth and Amount of Summerwood.

3. Dense Douglas fir shall show on one end or the other an average of at least six annual rings per inch and at least one-third summerwood measured over 3 in. on a line located as described hereinafter. Coarse-grained material, excluded by this rule, shall be acceptable provided that the amount of summerwood measured as described shall be at least one-half. Material in which the proportion of summerwood is not clearly discernible shall not be accepted.

Presence of Pith.

4. Any timber whose least dimension is less than 5 in. shall not show the pith on the inspection end; pieces whose least dimension is 5 in. or more may contain the pith.

Location of 3-in. Line.

5. (*a*) *Pith Present.* When the least dimension is 5 in. or more, the pith being present, the line over which the rate of growth and percentage of summerwood measurements shall be made, shall run from the pith to the corner farthest from the pith. The 3-in. line shall begin at a distance from the pith equal to 2 in. less than one-half the least dimension of the piece.

When the rings are very irregular it may be necessary to shift the line somewhat around the piece to get a fair average for inspection, but the distance from the pith to the beginning of the 3-in. line must not be changed.

(*b*) *Pith not Present.* For all pieces where the pith is not present the center of the 3-in. line shall be at the center of the end of the piece, and the direction of the 3-in. line shall be at a right angle to the annual rings.

(*c*) If a radial line of 3 in. cannot be obtained, the measurement shall be made over the entire radial line that is available.

B. STRUCTURAL GRADES.

III. DEFINITIONS.

Definitions. 6. The following definitions are used in connection with these specifications:

(*a*) *Sound and Tight Knot.*—A sound and tight knot is one which is solid across its face and which is as hard as the wood surrounding it; and is so fixed by growth or position that it will retain its place in the piece.

(*b*) *Encased Knot.*—An encased knot is one whose growth rings are not intergrown and homogeneous with the growth rings of the piece it is in. The encasement may be partial or complete; if intergrown partially or so fixed by growth or position that it will retain its place in the piece, it shall be considered a sound and tight knot.

(*c*) *Loose Knot.*—A loose knot is one not firmly held in place by growth or position.

(*d*) *Rotten Knot.*—A rotten knot is one not as hard as the wood it is in.

(*e*) *Measurement of Knots.*—In beams, the diameter of a knot on the narrow or horizontal face shall be taken as its projection on a line perpendicular to the edge of the timber. On the wide or vertical face, the smallest dimension of a knot shall be taken as its diameter.

In posts, the mean or average dimension of a knot on any face shall be taken as its diameter.

(*f*) *Ring Shake.*—A ring shake is an opening between two annual rings.

(*g*) *Round Shake.*—A round shake is a ring shake extending entirely around the perimeter of an annual ring.

(*h*) *Measurement of Shake.*—A round or ring shake shall be measured on its vertical projection.

(*i*) *Diagonal Grain (Including Cross and Spiral Grain).*—Diagonal grain is grain not parallel with all the edges of the piece, whether indicated by the direction of the annual rings or of the wood fibers.

IV. MANUFACTURE.

Manufacture. 7. Structural grades shall be of sound wood and well manufactured, with square edges.

V. PHYSICAL PROPERTIES.

Segregation by Uses.

8. The purchaser shall list materials under their different uses, so that material of the desired requirements may be furnished.

(*A*) *General Requirements.*

Division of Beams.

9. (*a*) For the limitation of knots and angle of grain a beam shall be considered as divided into three volumes as shown in Fig. 1.

(*b*) When beams are specified by the purchaser as of two-span length, volumes 1 and 2 shall be considered as extending between points located one-eighth the length of the beam from each end.

Knots.

10. Structural timber shall be free from rotten or unsound knots or knots in groups or clusters. Sound and tight knots, limited in size and position as hereinafter provided, will be permitted.

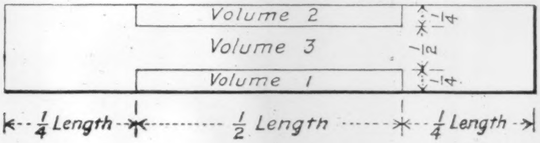

FIG. 1.

Angle of Grain.

11. (*a*) Beams shall not have diagonal or spiral grain in volumes 1 and 2 with slope greater than 1 in 20.

(*b*) Posts shall not have diagonal or spiral grain with slope greater than 1 in 15, unless otherwise specified by the purchaser.[1]

Shakes and Checks.

12. Round or ring shakes shall not occupy more than one-fourth the least dimension of either end of a timber. Any combination of checks or shakes which reduce the strength to a greater extent than the allowable round shakes will not be permitted. Shakes shall not show on any face of a timber.

Tension Members.

13. Defects in timber listed as tension members shall be limited as in beams, unless specified by the purchaser to be limited throughout the entire stick as in volumes 1 and 2 of beams.[2]

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[1] See Appendix, Section 4.

[2] See Appendix, Section 2.

Heart Requirement in Bridge and Trestle Timbers.

14. If specified by the purchaser, bridge and trestle timbers shall have the following heart requirements.

(*a*) Beams, stringers, girders and deep joists, caps, sills and posts shall show not less than 85 per cent of heart on each of the four sides, measured across the sides anywhere in the length of the piece.

(*b*) Longitudinal struts or girts shall show all heart on one face; the other face and two sides shall show not less than 85 per cent of heart, measured across the face or side anywhere in the length of the piece.

(*c*) Longitudinal cross braces, sash braces and sway braces shall show not less than 85 per cent of heart on two faces.

(*B*) *No. 1 Structural.*

Density and General Requirements.

15. No. 1 structural Douglas fir timbers shall be of dense Douglas fir and shall meet the preceding General Requirements.

Pitch Pockets and Wane.

16. They may have pitch pockets not over 6 in. long or $\frac{3}{8}$ in. wide and wane not to exceed 1 in. on one corner nor one-sixth the length of the piece.

Knots.

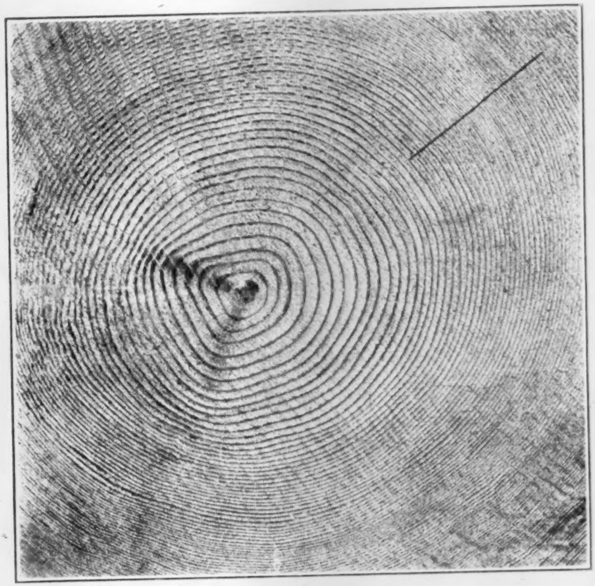
17. (*a*) *Loose Knots.*—Loose knots larger than $\frac{1}{2}$ in. shall not be permitted.

(*b*) *Beams, Stringers, Girders and Deep Joists.*—Beams, stringers, girders and deep joists shall not have in volumes 1 and 2 knots greater in diameter than one-fourth the width of the face in which they occur with a maximum of $1\frac{1}{2}$ in. in diameter. They shall not have in volume 3, on either end of the center half of a beam, knots larger than one-fourth the width of the face in which they occur. Knots within the center half of the length of a beam shall not exceed in the aggregate the width of the face in which they occur.

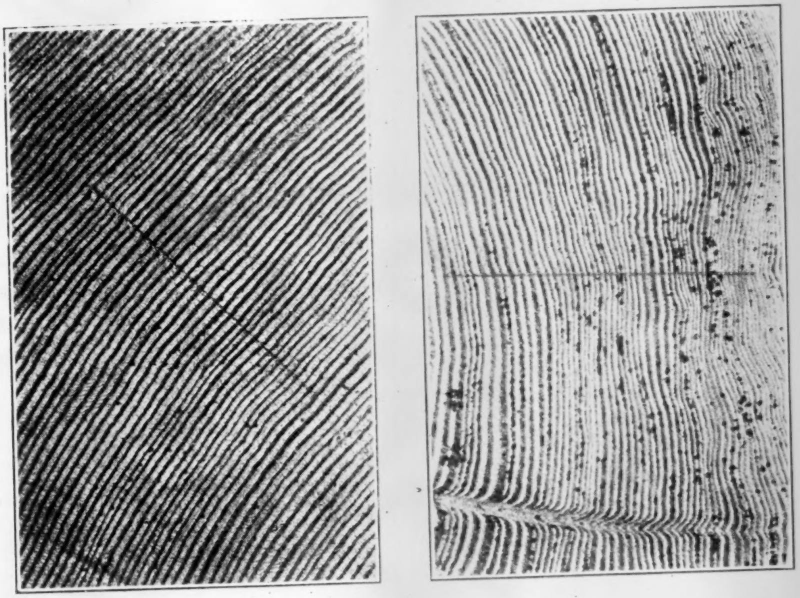
(*c*) *Caps, Sills and Posts.*—Caps, sills and posts shall be free from knots larger than one-fourth the width of the face in which they occur, with a maximum of 3 in. in diameter.

(*d*) *Longitudinal Struts or Girts.*—Longitudinal struts or girts shall be free from knots over 2 in. in diameter.

(*e*) *Longitudinal Cross Braces, Sash Braces and Sway Braces.*—Longitudinal cross braces, sash braces and sway braces shall be free from knots larger than one-third the width of the face in which they occur, with a maximum of 2 in. in diameter.



(*a*) When pith is present.



(*b*) When pith is not present.

FIG. 2.—Density Measurement, Showing Location of 3 in. Line.

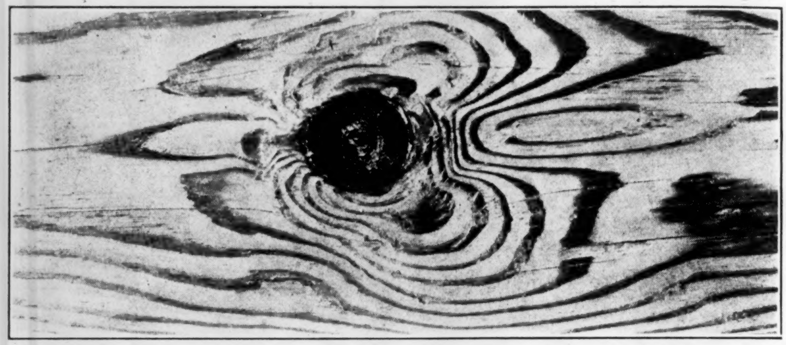


FIG. 3.—A Round Knot.

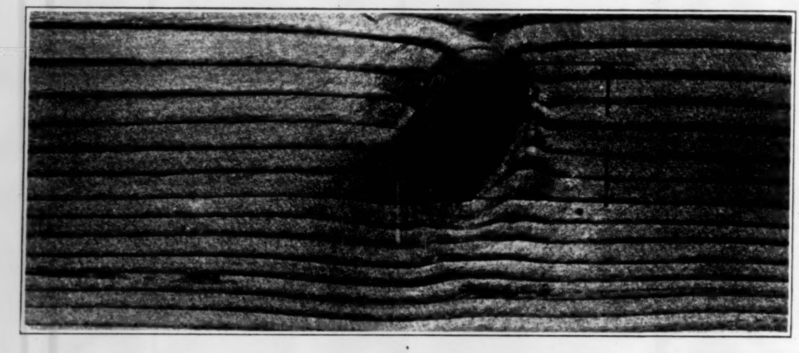


FIG. 4.—Measurement of a Knot, Measurement Perpendicular to the Edge of the Timber.

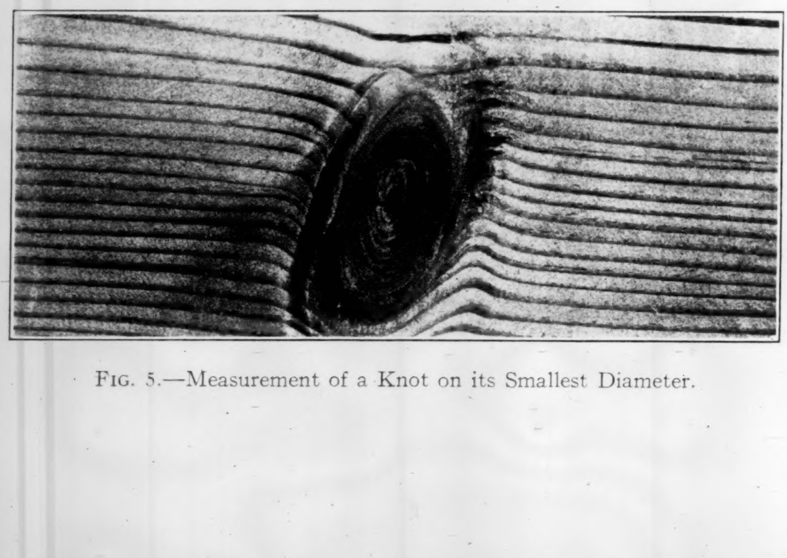


FIG. 5.—Measurement of a Knot on its Smallest Diameter.

(C) *No. 2 Structural.*

General Requirements.

18. No. 2 structural timbers shall meet the preceding General Requirements and shall include timbers not passing the No. 1 grade because of having:

(*a*) Less density than is required; or

(*b*) greater defects than are permitted.

Pitch Pockets and Wane.

19. They may have pitch pockets not longer than 12 in. or wider than $\frac{3}{8}$ in. and may have 2 in. wane on one corner or the equivalent on two or more corners of 10 by 10-in. timbers, with wane in proportion on smaller or larger sizes.

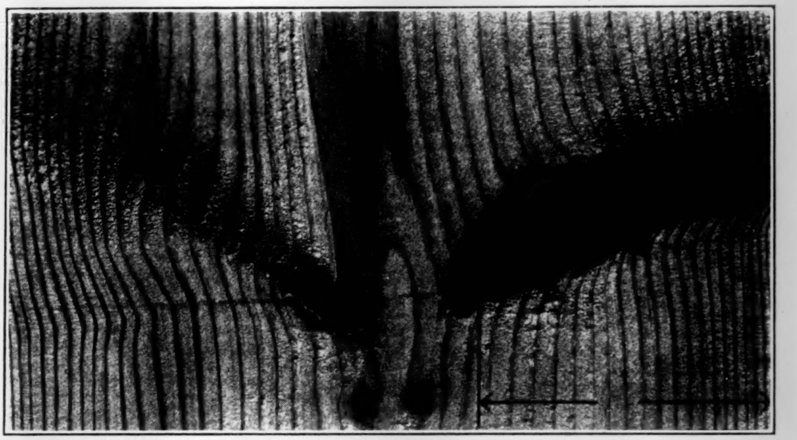


FIG. 6.—Measurement of a Spike Knot, Measurement Perpendicular to the Edge of the Timber.

Knots.

20. (*a*) *Loose Knots.*—Loose knots larger than one-half the size of the knots allowed shall not be permitted.

(*b*) *Beams, Stringers, Girders and Deep Joists.*—Beams, stringers, girders and deep joists shall not have in volumes 1 and 2 knots greater in diameter than as follows:

(1) If of dense Douglas fir, one-third the width of the face in which they occur with a maximum of 3 in.

(2) If not of dense Douglas fir, one-fourth the width of the face in which they occur with a maximum of $1\frac{1}{2}$ in.

They shall not have in volume 3, on either end of the center half of the beam, knots larger than one-third the width of the face in which they occur. They shall not have loose knots in volume 3 larger than $1\frac{1}{2}$ in. Knots within the center half of the length of a beam shall not exceed in the aggregate twice the width of the face in which they occur.

(*c*) *Caps and Sills.*—Caps and sills shall be free from knots larger than one-half the width of the face in which they occur with a maximum of 3 in. in diameter.

(*d*) *Posts.*—Posts shall be free from knots greater in diameter than as follows:

(1) If of dense Douglas fir, one-third the least dimension of the post with a maximum of 4 in.

(2) If not of dense Douglas fir, one-fourth the least dimension of the post with a maximum of 3 in.

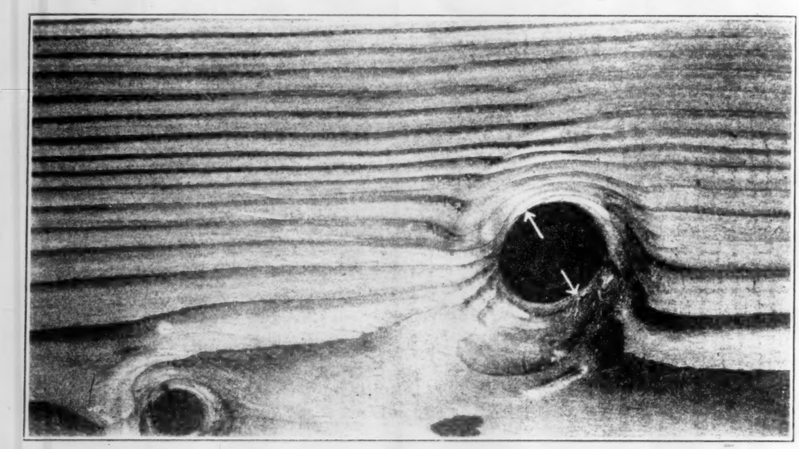


FIG. 7.—Measurement of the Mean Diameter of a Knot.

(*e*) *Longitudinal Struts or Girts.*—Longitudinal struts or girts shall be free from knots over 2 in. in diameter.

(*f*) *Longitudinal Cross Braces, Sash Braces and Sway Braces.*—Longitudinal cross braces, sash braces and sway braces shall be free from knots larger than one-third the width of the face in which they occur with a maximum of 2 in. in diameter.

VI. STANDARD SIZES.

Standard Size Rough.

21. Rough timbers shall be sawed to standard size and when green shall not be more than $\frac{1}{2}$ in. less than the nominal size specified.

Standard Size Green.

22. When timbers 4 by 4 in. or larger are ordered sized, they may when green be $\frac{1}{2}$ in. less than the nominal size specified, either S1S1E or S4S, unless otherwise specified.

APPENDIX.

The following information as to working stresses and the use and application of the Specifications for Structural Douglas Fir is important to a proper understanding of the specifications and is given below in the form of an Appendix to the Specifications. The appendix is not, however, a part of the specifications.

WORKING STRESSES.

1. The following working stresses are based upon recommendations by the Forest Products Laboratory, U. S. Forest Service, for Structural Douglas Fir:

	NO. 1 STRUCTURAL.	NO. 2 STRUCTURAL.[1]
Bending: Extreme Fiber Stress[2]		
Wet Location	1 100 lb. per sq. in.	900 lb. per sq. in.
Outside Location	1 400 " " "	1 100 " " "
Dry Location	1 600 " " "	1 300 " " "
Maximum Shear:		
Horizontal, All Locations[3]	100 " " "	90 " " "
Compression:		
Parallel to Grain[4]		
Wet Location	900 " " "	800 " " "
Outside Location	1 100 " " "	900 " " "
Dry Location	1 200 " " "	1 000 " " "
Perpendicular to Grain		
Wet Location	225 " " "	200 " " "
Outside Location	250 " " "	225 " " "
Dry Location	350 " " "	300 " " "
Elasticity:		
Average Modulus, All Locations[5]	1 600 000 " " "	1 400 000 " " "

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[1] In this grade pieces of exceptionally low density should not be placed in positions where they will receive long-continued loads producing maximum allowable stresses.

[2] Where timbers are in direct tension the same values as for extreme fiber stress in bending may be used. Wood has greater resistance to tension than to any other kind of stress and it has been found difficult to break it in a true tension test.

[3] These values are based on present inadequate information concerning the effect of seasoning on shearing values in Douglas fir, further investigation in regard to which is now under way.

[4] A short column is more likely to fail at the end than at any other point and the variations in moisture are greater there; for these reasons the same stresses should be used in end bearing as for short columns. For "long columns," that is, compression members with an unsupported length greater than about ten times their least diameter, these values should be reduced according to a column formula. Such formulas are given and discussed in the various text-books on mechanics, and in treatises on structural design.

[5] Timber constantly yields under long-continued heavy loading, and will fail finally at a load little more than half that required to break it when applied rapidly in a test; for application to a beam which is to be subjected to long-continued loading, therefore, moduli of elasticity one-half those given above should be used.

USE OF THE DENSITY AND STRUCTURAL GRADING RULES.

2. When timbers to be used in direct tension are designed for full working stresses, defects throughout the entire stick should be limited as in volumes 1 and 2 of beams.

3. When beams are of two-span length, volumes 1 and 2 should be considered as extending between points located one-eighth the length of the beam from each end.

4. When posts are designed for less than full working stresses, the angle of grain may be increased proportionately to the reduction in stress; that is, with a working stress one-half the full working stress allowed, the angle of grain may be 1 in $7\frac{1}{2}$.

5. Dense material may be obtained in any commercial grade and independently of structural properties; density should be required where strength or resistance to abrasion or decay are factors.

6. For sills, caps, plates and other members where bending stresses are low compared with compression across the grain, density should be required but special limitation as to sound knots and angle of grain is not necessary.

7. For posts, where large sizes are required for harmony with the balance of the construction and where resistance to decay is not an important factor, timbers without density requirement may be used.

8. For studding and wall construction, where the spacing of members is governed by requirements for nailing or supports to wall covering, commercial grades without density requirement may be used.

9. For joists, where stiffness is a controlling factor rather than bending stresses or resistance to decay, density need not be required, there being only slightly greater stiffness in dense material.

10. Heartwood and sapwood are of equal strength but when durability is a factor, as in exposure to decay-producing conditions, sapwood should be limited or all heartwood be required.

INSPECTION OF STRUCTURAL GRADES.

11. The rules for structural grades contain minimum requirements and maximum defects, all of which may be present at

one time; when a particular timber is slightly below the provisions of the grade in some of these properties and somewhat above in others the relative effect should be considered in accepting or rejecting it.

REINSPECTION OF DENSE DOUGLAS FIR.

12. No arbitrary rules for the inspection of lumber can be maintained with satisfaction. Inspection of lumber is not an exact science, and a reasonable variation of opinion between inspectors should be recognized.

13. Upon reinspection of dense Douglas fir, all timbers having one-third or more summerwood shall be accepted as of grade. For every three timbers thus accepted, one of the remaining timbers having between 30 and $33\frac{1}{3}$ per cent summerwood shall also be included.

14. Any remaining material having more than 30 per cent summerwood, and also all material found to have less than 30 per cent, shall be received as not of grade, with settlement subject to agreement between shipper and purchaser.

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TENTATIVE SPECIFICATIONS FOR ASPHALT FOR USE IN DAMP-PROOFING AND WATERPROOFING.[1]

Serial Designation: D 40 – 17 T.

These specifications are issued under the fixed designation D 40; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917.

Material Covered. 1. These specifications cover asphalt for use in damp-proofing and waterproofing, designated as type A, recommended for use under uniformly moderate temperature conditions.

I. PROPERTIES.

Melting Point. 2. The melting point shall be between 38 and 60° C. (100 and 140° F.) as determined by the ring-and-ball method in water bath, and shall be specified for one of the following classes: 54.5 to 60° C. (130 – 140° F.); 46 to 54°.5 C. (115 – 130° F.); 38 to 46° C. (100 – 115° F.). The Standard Method for Determination of Softening Point of Bituminous Materials other than Tar Products (Serial Designation: D 36) of the American Society for Testing Materials[2] shall be used.

Penetration. 3. The penetration at 25° C. (77° F.) under load of 100 g.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1921, to Mr. Leroy M. Law, Secretary of Committee D-8 on Waterproofing, Maison-Blanche Annex, New Orleans, La.

[2] A.S.T.M. Standards Adopted in 1919.

for 5 seconds, as determined by the Standard Test for Penetration of Bituminous Materials (Serial Designation: D 5) of the American Society for Testing Materials,[1] shall be not less than 50 nor more than 125.

The penetration shall bear the following relation to the melting point:

Penetration of 50 to 75 for melting points between 54.5 and 60° C. (130 and 140° F.).
Penetration of 75 to 100 for melting points between 46 and 54°.5 C. (115 and 130° F.).
Penetration of 100 to 125 for melting points between 38 and 46° C. (100 and 115° F.).

Ductility.

4. The ductility[2] at 25° C. (77° F.), when a briquette of the material having a minimum cross-section of 1 sq. cm. is pulled apart at the rate of 5 cm. per minute, shall not be less that 30 cm.

Specific Gravity.

5. The specific gravity shall not be more than 1.08 at 25/25° C. (77/77° F.).

Soluble in Carbon Bisulfide.

6. The bitumen soluble in cold carbon bisulfide, as determined by the method in Section 10, shall not be less than 95 per cent.

Loss on Heating.

7. The loss of a 50-g. sample on heating at 163° C. (325° F.) for 5 hours, as determined by the Standard Test for Loss on Heating of Oil and Asphaltic Compounds (Serial Designation: D 6) of the American Society for Testing Materials,[1] shall not exceed 1 per cent. The penetration of the residue from this test shall be not less than 50 per cent of the original penetration specified in Section 3.

Ash.

8. The ash, as determined by the method in Section 10, shall not exceed 4 per cent.

II. METHODS OF TESTING.

9. *Specific Gravity.*—The specific gravity may be determined by any approved method, but some method similar to the following is recommended:

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[1] 1918 Book of A.S.T.M. Standards.

[2] A detailed description of the mold and method to be followed is given in Appendix IV, Report of Committee D-4 on Road Materials, *Proceedings*, Am. Soc. Test. Mats., Vol. XV, Part I, p. 349 (1915).

Weigh accurately in air a small platinum pan or crucible supported in a wire sling and suspended by a fine platinum wire or silk thread; record the weight as weight A. Then weigh it in a like manner completely immersed in freshly distilled water at 25° C. (77° F.) except for the fine platinum wire or silk thread. Record this weight as weight B. Then bring the crucible to red heat, cool and almost fill with asphalt which has been melted at the lowest possible temperature. Cool the crucible and contents to room temperature, place in the sling and weigh in air. Record the weight as weight C. Then weigh crucible and contents at 25° C. (77° F.) suspended as before in water, and record this weight as weight D. From these four weights the specific gravity may be calculated from the following formula:

$$\text{Specific Gravity} = \frac{C-A}{(C-A)-(D-B)}.$$

10. *Bitumen Soluble in Cold Carbon Bisulfide; Ash.*—For this test weigh accurately 1 to 2 g. of asphalt into an Erlenmeyer flask. Pour 100 cc. of c. p. carbon bisulfide into the flask in small portions, with continual agitation, until all lumps disappear and nothing adheres to the bottom. Cork the flask and set aside for 15 minutes. Then filter the solution by suction through an asbestos pad in a Gooch crucible (the best size of crucible for this test is 4.4 cm. wide at the top tapering to 3.6 cm. at the bottom, and 2.5 cm. deep), which has been previously prepared and weighed. Care shall be exercised in decanting the liquid portion. Stop the decantation at the first sign of sediment coming out. Wash the sides of the flask with a small amount of fresh carbon bisulfide and bring the sediment upon the felt, using a "policeman," if necessary, to remove all adhering material. Then wash the material on the mat with carbon bisulfide until the washings are colorless and continue suction until the odor of carbon bisulfide is hardly detectable. Then clean the outside of the crucible with a cloth moistened with a small amount of solvent. Dry the crucible with contents for one-half hour at 105° C. (221° F.), cool in a desiccator and weigh.

The total weight of insoluble material includes both organic and inorganic insoluble. If organic insoluble material is present, heat the crucible to red heat until no carbonaceous particles remain,—leaving only the mineral ash,—cool and weigh, The percentage soluble in carbon bisulfide, the organic insoluble. if there is any present, and the ash should total 100 per cent. Each should be reported.

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TENTATIVE SPECIFICATIONS
FOR
PRIMER FOR USE WITH ASPHALT FOR USE IN DAMP-PROOFING AND WATERPROOFING.[1]

Serial Designation: D 41 – 17 T.

These specifications are issued under the fixed designation D 41; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917.

Material Covered. 1. These specifications cover primer for use, when specified, with asphalt for use in damp-proofing and waterproofing.

Primer. 2. The primer shall consist of an asphaltic base, complying in every respect with the Tentative Specifications for Asphalt for Use in Damp-proofing and Waterproofing (Serial Designation: D 40 – 17 T) of the American Society for Testing Materials[2] for use below grade, which shall be thinned to ordinary paint consistency with a petroleum distillate having an end point on distillation not above 260° C. (500° F.). Not more than 20 per cent of this petroleum distillate shall distill under 120° C. (248° F.).

The distillation shall be carried out according to the Standard Tests for Paint Thinners other than Turpentine (Serial Designation: D 28) of the American Society for Testing Materials.[3]

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1921, to Mr. Leroy M. Law, Secretary of Committee D-8 on Waterproofing, Maison-Blanche Annex, New Orleans, La.

[2] See p. 716.

[3] 1918 Book of A.S.T.M. Standards.

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TENTATIVE SPECIFICATIONS
FOR
COAL-TAR PITCH FOR USE IN DAMP-PROOFING AND WATERPROOFING.[1]

Serial Designation: D 42 – 17 T.

These specifications are issued under the fixed designation D 42; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917.

Material Covered. 1. These specifications cover coal-tar pitch for use in damp-proofing and waterproofing, designated as type A, recommended for use under uniformly moderate temperature conditions.

I. PROPERTIES.

Melting Point. 2. The melting point, as determined by the cube method in water bath, Section 9, shall be between 49 and 60° C. (120 and 140° F.). In specifying the melting point desired within the above limits, a variation of not more than 2°.5 C. (5° F.) in either direction will be permitted.

Penetration. 3. The penetration at 25° C. (77° F.) under load of 100 g. for 5 seconds, as determined by the Standard Test for Penetration of Bituminous Materials (Serial Designation: D 5) of the American Society for Testing Materials,[2] shall not be less than 20 nor more than 120.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1921, to Mr. Leroy M. Law, Secretary of Committee D-8 on Waterproofing, Maison-Blanche Annex, New Orleans, La.

[2] 1918 Book of A.S.T.M. Standards.

Ductility. 4. The ductility[1] at 25° C. (77° F.). when a briquette of the material having a minimum section of 1 sq. cm. is pulled apart at the rate of 5 cm. per minute, shall not be less than 40 cm.

Loss on Heating. 5. The loss of a 20-g. sample on heating at 163° C. (325° F.) for 5 hours, as determined by the Standard Test for Loss on Heating of Oil and Asphaltic Compounds (Serial Designation: D 6) of the American Society for Testing Materials,[2] on pitch of melting point between 49 and 54°.5 C. (120 and 130° F.) shall not exceed 9 per cent and on pitch of melting point between 54.5 and 60° C. (130 and 140° F.) shall not exceed 7 per cent.

Specific Gravity. 6. The specific gravity of the pitch at 25/25° C. (77/77° F.) shall not exceed the limits 1.24 and 1.34.

The specific gravity at 60/60° C. (140/140° F.) of the distillate to 355° C. (671° F.) shall not be less than 1.06.

Soluble Matter. 7. The matter soluble in hot toluol-benzol, as determined by the method in Section 12, shall not be less than 65 nor more than 85 per cent.

Ash. 8. The ash, as determined by the method in Section 13, shall not exceed 1 per cent.

II. METHODS OF TESTING.

9. *Melting Point.*—The melting point shall be the temperature at which the pitch formed in a $\frac{1}{2}$-in. cube and suspended in a vessel of water 1 in. above the bottom shall touch the bottom of this vessel. The cube is formed by pressing the pitch in a suitable mold. Remove the cube from the mold and suspend on the lower arm of a No. 12 B. & S. gage wire bent at right angles. The wire should be passed through the center of two opposite faces of the cube. Immerse the cube in 400 cc. of freshly boiled distilled water at a temperature of 15°.5 C. (60° F.) contained in a 600-cc. beaker. Maintain this temperature until the pitch is the same temperature as the water. Apply heat in such a manner that the temperature of the water is raised 5° C. (9° F.) per minute, until the pitch touches the bottom of the beaker. At this point the temperature, recorded

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[1] A detailed description of the mold and method to be followed is given in Appendix IV, Report of Committee D-4 on Road Materials, *Proceedings*, Am. Soc. Test. Mats., Vol. XV, Part I, p. 349 (1915).

[2] 1918 Book of A.S.T.M. Standards; use a 20-g. sample instead of the 50-g. sample specified.

by a thermometer whose bulb shall be level with the cube, shall be considered as the melting point of the pitch.

10. *Specific Gravity.*—The specific gravity may be determined by any approved method, but some method similar to the following is recommended:

Weigh accurately in air a small platinum pan or crucible supported in a wire sling and suspended by a fine platinum wire or silk thread; record the weight as weight A. Then weigh it in a like manner completely immersed in freshly distilled water at 25° C. (77° F.), except for the fine platinum wire or silk thread. Record this weight as weight B. Then bring the crucible to red heat, cool and almost fill with pitch which has been melted at the lowest possible temperature. Cool the crucible and contents to room temperature, place in the sling and weigh in air. Record the weight as weight C. Then weigh crucible and contents at 25° C. (77° F.) suspended as before in water, and record this weight as weight D. From these four weights the specific gravity may be calculated from the following formula:

$$\text{Specific Gravity} = \frac{C-A}{(C-A)-(D-B)}.$$

11. *Specific Gravity of Distillate.*—Distill in a glass or metal retort, preferably of 8-oz. capacity, at least 100 g. of the pitch to 355° C. (671° F.) vapor temperature, catching the distillate. The specific gravity may be determined by any approved method, but the following is recommended:

Clean a 10-cc. specific-gravity bottle; dry and weigh. Fill it with distilled water and heat to 60° C. (140° F.) as described below; dry and weigh. Then fill the bottle with distillate, immerse in water and heat slowly to 60° C. (140° F.), maintaining this temperature for at least 5 minutes. Dry, cool and weigh. From these weights the specific gravity may be determined from the following formula:

$$\text{Specific Gravity} = \frac{\text{Weight of bottle} + \text{distillate} - \text{weight of bottle.}}{\text{Weight of bottle} + \text{water} - \text{weight of bottle}}$$

12. *Matter Insoluble in Hot Toluol-Benzol Extraction.*[1]—In

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[1] A full description of a simple apparatus for this test may be found in the *Journal of Industrial and Engineering Chemistry*, Vol. 6, pp. 279–285.

testing materials of 5 per cent or more insoluble matter 5 g. should be taken for the test. With lesser percentages 10 g. should be used. Weigh out the amount in a 100-cc. beaker, and digest with about 50 cc. of c. p. toluol on the steam bath, for a period not to exceed 30 minutes. If the solution is kept hot and constantly stirred, the digestion can be completed very rapidly. Weigh a filter cup, previously prepared, in a weighing bottle and place in a carbon filter tube over a beaker or flask. Decant the toluol-tar mixture through the thimble and wash with hot c. p. toluol until clean, using some form of "policeman" which is unaffected by toluol, for the purpose of detaching any residue which may adhere to the beaker. Finally, wash the cup with hot c. p. benzol and then, after draining, cover with a cap of filter paper or alundum, and place in the extraction apparatus in which the c. p. benzol is used as solvent. Continue the extraction until the descending benzol is colorless. Remove the thimble, take off the cap, dry in the steam oven and weigh in the weighing bottle after cooling in the desiccator. The balance used for this work should be accurate to at least ½ mg. It is well to examine the insoluble residue for foreign matter such as wood, slivers, pieces of bagging, etc. If such foreign matter is present, the test should be rejected.

13. *Ash.*—This determination is made by burning to ash a 1-g. sample of the material in a weighed platinum crucible or dish of sufficient size. Apply heat gently until the pitch ignites, then withdraw the heat. After the pitch ceases to burn, apply the heat again until the residue is burned free of carbon. Then cool the crucible and contents, weigh, and determine the ash.

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TENTATIVE SPECIFICATIONS

FOR

CREOSOTE OIL FOR PRIMING COAT WITH COAL-TAR PITCH FOR USE IN DAMP-PROOFING AND WATERPROOFING.[1]

Serial Designation: D 43 – 17 T.

These specifications are issued under the fixed designation D 43; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917.

Material Covered. 1. When it is specified that previous to the mopping on of the hot coal-tar pitch, the wall, floor, or foundation shall be painted with a priming coat, the following specifications for creosote oil shall apply:

Definition. 2. Creosote oil shall be a pure tar distillate free from any substance foreign to a tar distillate.

Melting Point. 3. The oil shall be entirely fluid at 38° C. (100° F.).

Specific Gravity. 4. The specific gravity at 38° C. (100° F.) shall not be less than 1.00 nor more than 1.06.

Insoluble Matter. 5. Insoluble matter in hot benzol shall be less than 1 per cent.

Distillation. 6. When distilled in accordance with the Standard Methods for Sampling and Analysis of Creosote Oil (Serial Designation: D 38) of the American Society for Testing Materials,[1] it shall yield:

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1921, to Mr. Leroy M. Law, Secretary of Committee D-8 on Waterproofing, Maison-Blanche Annex, New Orleans, La.

(*a*) Water, not more than 2 per cent.

(*b*) Not more than 5 per cent shall distill under 200° C. (392° F.).

(*c*) Not more than 50 nor less than 30 per cent shall distill under 235° C. (455° F.).

(*d*) The residue above 355° C. (671° F.) shall not exceed 15 per cent.

(*e*) The residue shall be soft.

(*f*) The specific gravity at 38° C. (100° F.) of the fraction distilling between 235 and 315° C. (455 and 599° F.) shall not be less than 1.00.

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[1] 1918 Book of A.S.T.M. Standards.

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TENTATIVE SPECIFICATIONS
FOR
WOODEN BOXES, NAILED AND LOCK-CORNER CONSTRUCTION, FOR THE SHIPMENT OF CANNED FOODS.[1]

Serial Designation: D 44 - 20 T.

These specifications are issued under the fixed designation D 44; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917; REVISED, 1920.

Canned Foods Boxes.

Wooden boxes of nailed and lock-corner construction for the shipment of canned foods shall comply with the Tentative General Specifications for Wooden Boxes, Nailed and Lock-Corner Construction (Serial Designation: D 68 - 20 T) of the American Society for Testing Materials,[2] except as otherwise provided in the following table:

Commodity.	Type of Box Construction.	Minimum Thickness of Material, in.[1]			Maximum Gross Weight of Box and Contents, lb.	Permissible Variations in Inside Dimensions of Boxes.
		Ends.	Sides.[2]	Top and Bottom.[2]		
Canned Foods in Metal Cans (Fish, Meats, Fruits, Vegetables and Other Foods)	Nailed	$\frac{5}{8}$	$\frac{5}{16}$	$\frac{5}{16}$	90	Inside dimensions of boxes shall not exceed the exact length and width of contents by more than $\frac{1}{4}$ in., nor the exact depth of contents by more than $\frac{1}{4}$ in.
	Lock-Corner	$\frac{7}{16}$	$\frac{7}{16}$	$\frac{5}{16}$	50	
		$\frac{1}{2}$	$\frac{5}{16}$	$\frac{5}{16}$	50	
		$\frac{5}{8}$	$\frac{5}{16}$	$\frac{5}{16}$	90	

NOTE 1.—The thicknesses specified apply to boxes of Group I, II and III woods. When woods in Group IV are used the thicknesses may be $\frac{1}{16}$ in. less than those specified.

NOTE 2.—When one-piece sides and two-piece tops and bottoms of woods of Groups I and II are used, material may be $\frac{1}{32}$ in. thinner than specified. When rotary-cut gum lumber is used in one-piece sides and tops and not more than two-piece bottoms, the thickness may be $\frac{1}{16}$ in. less than specified for woods of Group III, minimum thickness $\frac{1}{4}$ in.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1921, to Mr. J. A. Newlin, Chairman of Committee D-10 on Shipping Containers, Forest Products Laboratory, Madison, Wis.

[2] See p. 730.

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TENTATIVE SPECIFICATIONS
FOR
CANNED FOODS BOXES, WIREBOUND CONSTRUCTION.[1]

Serial Designation: D 45 – 17 T.

These specifications are issued under the fixed designation D 45; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917.

I. MANUFACTURE.

Manufacture.

1. Boxes shall be well manufactured from sound (free from decay or dote), well-seasoned veneer and cleat lumber. Kiln-drying by excessively high temperatures or low humidities or below 6 per cent moisture shall be avoided. Veneer shall be free from knot holes, loose or rotten knots greater than 1 in. in diameter. Cleats shall be free from knots and from excessive cross grain. No knots will be permitted which will interfere with proper nailing or stapling. Each side, top, and end shall be of a single piece of veneer; the bottoms shall consist of not more than two pieces, no piece less than 4 in. in width.

Nos. 2½ and 3 Cans.

2. Boxes for two dozen No. 2½, two dozen No. 3, and two dozen extra size No. 3 cans shall be constructed as follows:

(*a*) *Cleats.*—Each end shall be cleated with four cleats not less than $\frac{15}{16}$ by $\frac{11}{16}$ in., or any other size cleats that have equally large cross-section. One end of each cleat shall be provided with a tenon $\frac{1}{4}$ in. thick and $\frac{15}{16}$ in. long and the other end with the corresponding mortise. Cleats may be made of any of the following species of wood:

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1921, to Mr. J. A. Newlin, Chairman of Committee D-10 on Shipping Containers, Forest Products Laboratory, Madison, Wis.

Red gum
Black gum
Maple
Birch
Beech
Tupelo
Elm
Oak
Sycamore
Ash
Hickory
Hackberry
Yellow pine

(*b*) The sides, top, bottom and ends shall be of $\frac{1}{8}$-in. gum[1] veneer. The box shall be bound with four equally spaced 16-gage 0.0625-in. diameter, basic annealed wires. End wires shall be attached to cleats with 16-gage by $1\frac{1}{8}$-in. bright, soft Bessemer staples driven through the veneer into the center of the width of the cleats. Six staples shall be driven into each top and bottom cleat and four into each side cleat. Interior wires shall be attached to the veneer by 18-gage, bright, soft Bessemer staples driven through and clinched; six staples connecting each wire to top and bottom and four to each side.

(*c*) The ends shall be attached to each side cleat by four 18-gage by $\frac{13}{16}$-in. staples equally spaced, driven into the center of the cleat and at an angle of 45 to 60 deg. with the grain of the end; or by four nails $\frac{7}{8}$-in. by 15-gage by $\frac{1}{4}$-in. head, driven into the center of the cleat and equally spaced.

Nos. 1 and 2 Cans.

3. Boxes for two dozen No. 1, four dozen No. 1, and two dozen No. 2 cans shall be constructed as follows:

These boxes shall be the same as those for No. 3 cans, except that wires shall be stapled to the tops and bottoms with four staples to each wire and to the sides with three staples to each wire.

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[1] Specifications for boxes of other kinds of veneer and with cleats of other species than those listed have been withheld pending tests.

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TENTATIVE GENERAL SPECIFICATIONS FOR WOODEN BOXES, NAILED AND LOCK-CORNER CONSTRUCTION.[1]

Serial Designation: D 68 – 20 T.

These specifications are issued under the fixed designation D 68; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1920.

Types of Boxes Covered. 1. These specifications are intended to apply to wooden boxes of nailed and lock-corner construction, and are directly applicable to the styles of boxes illustrated in Fig. 1.

I. MATERIAL.

Seasoning. 2. The lumber shall be thoroughly seasoned, that is, shall have an average moisture content of 12 to 18 per cent, based on the weight of the wood after oven-drying to a constant weight.

Defects. 3. All defects[2] in the lumber that materially lessen the strength of the part, expose contents to damage, or interfere with proper nailing, shall be eliminated.

Manufacture. 4. Ends, sides, tops, bottoms and other parts of a box shall be well manufactured and cut true to size.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1921, to Mr. J. A. Newlin, Chairman of Committee D-10 on Shipping Containers, Forest Products Laboratory, Madison, Wis.

[2] The committee recognizes that the limitations on defects are not sufficiently definitive. This phase is being made the subject of careful study with the object of recommending more definite requirements

II. GROUPING OF WOODS.

Grouping of Woods.

5. The principal woods used for boxes are classed for the purpose of specifications into four groups, as follows:

GROUP I.

White pine
Norway pine
Aspen (Popple)
Spruce
Western (yellow) pine
Cottonwood
Yellow poplar
Balsam fir
Chestnut
Sugar pine
Cypress
Basswood
Willow
Noble fir
Magnolia
Buckeye
White fir
Cedar
Redwood
Butternut
Cucumber
Alpine fir
Lodgepole pine
Jack pine

GROUP II.

Southern yellow pine
Hemlock
North Carolina pine
Douglas fir
Larch (Tamarack)

GROUP III.

White elm
Red gum
Sycamore
Pumpkin ash
Black ash
Black gum
Tupelo
Maple, soft or silver

GROUP IV.

Hard maple
Beech
Oak
Hackberry
Birch
Rock elm
White ash
Hickory

III. DIMENSIONS OF PARTS.

Thickness of Parts.

6. (*a*) The thicknesses called for in specifications for boxes of any given commodity will, unless otherwise specified, be understood as applying to woods of Groups I and II.

(*b*) When the material is specified (for Group I and II woods) of the thicknesses indicated in the following table, woods of Groups III and IV may be used with the following permissible reductions in thickness:

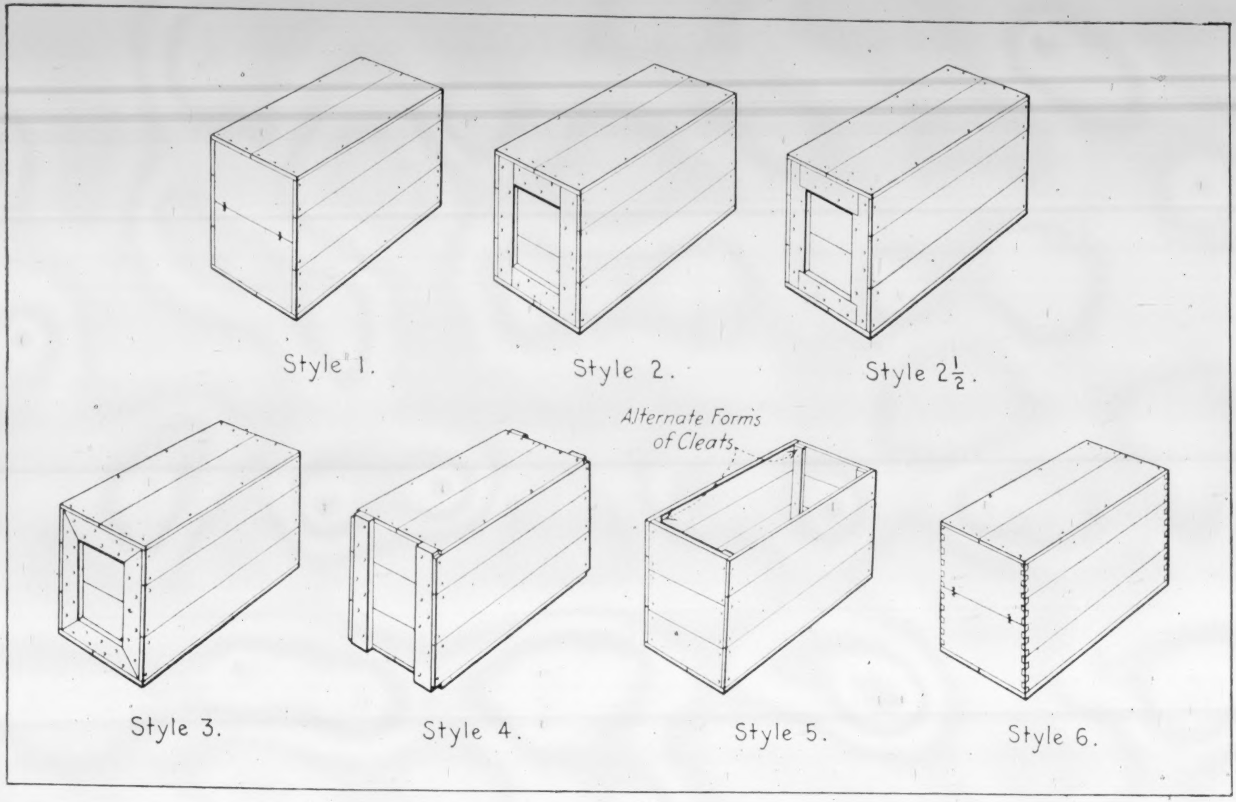
Style 1.
Style 2.
Style 2½.
Alternate Forms of Cleats.
Style 3.
Style 4.
Style 5.
Style 6.

FIG. 1.—Styles of Wooden Boxes, Nailed and Lock-Corner Construction.

SPECIFIED THICKNESS OF PARTS (GROUP I AND II WOODS)	ALLOWABLE REDUCTION IN THICKNESS IF GROUP III AND IV WOODS ARE USED.
$\frac{5}{16}$ to $\frac{1}{2}$ in., incl.	$\frac{1}{16}$ in.
Over $\frac{1}{2}$ to 1 in., incl.	$\frac{1}{8}$ in.
" 1 " 2 in., "	$\frac{1}{4}$ in.

Permissible Variation in Thickness of Parts.

7. The permissible variation below the thickness of parts specified in Section 6 shall not exceed one-eighth of the thickness of the part.

Width of Parts.

8. (*a*) The maximum number of pieces allowed in any side, top, bottom or end of a box shall be as follows:

WIDTH OF FACE.	MAXIMUM NUMBER OF PIECES.
5 in. or under	1
Over 5 to 8 in., incl.	2
" 8 " 12 in., "	3
" 12 " 20 in., "	4
For each additional 5 in. in width of face	1 additional piece may be used

(*b*) Two or more pieces Lindermann-jointed shall be considered as one piece. No piece less than $2\frac{1}{2}$ in. in width of face at either end may be used in any part, except for cleats or battens.

IV. MANUFACTURE OF BOXES.

Surfacing of Boxes.

9. The outside surfaces of boxes shall be sufficiently smooth to permit of legible marking.

Joining.

10. (*a*) Ends 1 in. or less in thickness, if made of two or more pieces, shall be either (1) butt jointed or matched and fastened with two or more corrugated fasteners; or (2) cleated.

(*b*) The size of corrugated fasteners to be used shall be as follows:

THICKNESS AT ENDS.	SIZE OF CORRUGATED FASTENERS.
$\frac{7}{16}$ in.	1 by $\frac{3}{8}$ in.
$\frac{5}{8}$ in.	1 by $\frac{1}{2}$ in.
$\frac{3}{4}$, $\frac{13}{16}$ and $\frac{7}{8}$ in.	1 by $\frac{5}{8}$ in.

Schedule of Nailing.

Kinds of Nails.

11. (*a*) All nails specified in these specifications are standard cement-coated box nails.

(*b*) If other than cement-coated nails are used, 25 per cent more nails shall be driven than specified for cement-coated nails. Plain nails driven through and clinched may be used for cleating.

Size of Nails.

12. The size of nails to be used is determined by the species and thickness of the material in which the points of the nails are held, and shall be in accordance with the following table:

SIZE OF CEMENT-COATED NAILS FOR DIFFERENT SPECIES AND THICKNESS OF MATERIAL.

(The sizes of nails are given in "penny".)

Species of Wood Holding Nails.	Thickness of Ends or Cleats to Which Sides, Tops and Bottoms are Nailed, in.								Thickness of Sides to Which Top and Bottom are Nailed, in.		
	$\frac{3}{8}$ or less	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{11}{16}$ or $\frac{3}{4}$	$\frac{13}{16}$	$\frac{7}{8}$	Less than $\frac{1}{2}$	$\frac{1}{2}$ to $\frac{9}{16}$	$\frac{5}{8}$ to $\frac{7}{8}$
Group I woods	4	5	5	6	7	8	8	9	4	6	7
Group II woods	4	4	5	5	6	7	7	8	4	5	6
Group III woods	3	4	4	5	5	6	7	7	3	4	5
Group IV woods	3	3	4	4	4	5	6	7	3	4	5

NOTE.—If the designated penny of nail is not available, the next lower penny shall be used, and the nails spaced proportionately closer.

Spacing and Number of Nails.

13. (*a*) The spacing of nails holding the side, top or bottom to the ends of a box shall be as follows:

SIZE OF NAILS, "PENNY."	SPACE WHEN DRIVEN INTO	
	SIDE GRAIN OF END.	END GRAIN OF END.
6 or less	2 in.	$1\frac{3}{4}$ in.
7	$2\frac{1}{4}$ "	2 "
8	$2\frac{1}{2}$ "	$2\frac{1}{4}$ "
9	$2\frac{3}{4}$ "	$2\frac{1}{2}$ "
10	3 "	$2\frac{3}{4}$ "

(In order to ascertain the number of nails to be used, divide the width of the side, top or bottom (or length of cleat) by the spacing specified for the size of nails to be used. Fractions in the result greater than $\frac{1}{4}$ if the points of nails are to be held in the end grain, and greater than $\frac{1}{2}$ if the points of nails are to be held in the side grain, will be considered as a whole number.)

(*b*) The spacing of nails holding the top and bottom to the sides of a box shall be 6 to 8 in. When material in the sides is less than $\frac{1}{2}$ in. in thickness, side nailing shall not be used unless otherwise specified.

(*c*) No board shall have less than two nails at each nailing end. Where cleats of thickness not less than the thickness of the ends are used, approximately 50 per cent of the nails shall be driven into the cleats.

Driving of Nails.

14. Nails shall be driven flush.

(Over-driving of nails materially weakens the container.)

Strapping.

15. Specification to be supplied by the committee when the information is available.

AMERICAN SOCIETY FOR TESTING MATERIALS
PHILADELPHIA, PA., U. S. A.
AFFILIATED WITH THE
INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE SPECIFICATIONS
FOR
INSULATED WIRE AND CABLE: 30-PER-CENT HEVEA RUBBER.[1]

Serial Designation: D 27 – 16 T.

These specifications are issued under the fixed designation D 27; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1916.

Material Covered. 1. These specifications cover conductors and rubber insulation only. The design and factor of safety depend upon the service conditions and shall be at the option of the purchaser.

(A) *Conductor.*

I. MANUFACTURE.

Material. 2. The conductor shall be made of soft annealed copper, properly tinned, and have the properties and characteristics herein required.

Strand. 3. Each individual wire of a stranded conductor shall be considered separately and shall be designated as a strand.

Shape. 4. Each solid conductor and each strand shall be round and reasonably free from imperfections.

Stranding. 5. The stranding shall be concentric, unless otherwise specified, and shall conform to Table I.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1921, to Mr. F. M. Farmer, Chairman of Committee D-11 on Rubber Products, Electrical Testing Laboratories, Eightieth St. and East End Ave., New York City.

Density. 6. For the purpose of calculating weights, cross-sections, etc., in conductivity determinations, the density of the copper shall be taken as 8.89. See Appendix I.

TABLE I.—STRANDING.

ASSOCIATION OF RAILWAY ELECTRICAL ENGINEERS.)

Sizes.	Minimum Number of Strands in Conductor.
2 000 000 to 1 600 000 C. M.	127
1 500 000 " 1 100 000 "	91
1 000 000 " 550 000 "	61
500 000 " 250 000 "	37
No. 0000 " No. 1 A. w. g. or B. & S.	19
No. 2 " No. 8 "	7
Smaller sizes	1

II. PHYSICAL PROPERTIES AND TESTS.

Tensile Properties. 7. Each solid conductor or strand shall be so drawn and annealed that after tinning it shall conform to the properties given in Table II.

TABLE II.—TENSILE PROPERTIES.

AMERICAN SOCIETY FOR TESTING MATERIALS.

Diameter, in.	Maximum Tensile Strength, lb. per sq. in.	Minimum Elongation in 10 in., per cent.
0.460 to 0.290 Incl.	36 000	35
0.289 " 0.103 "	37 000	30
0.102 " 0.021 "	38 500	25
0.020 " 0.003 "	40 000	20

Tension Tests. 8. (*a*) *Method of Test.*—Tensile tests shall be made on fair samples and the elongation shall be determined as the permanent increase in length, due to the breaking of the wire in tension, measured between bench marks originally 10 in. apart. The specimen shall break between the bench marks and not closer than 1 in. to either mark.

(*b*) *Number of Tests.*—Samples shall be taken in accordance with Section 16.

(*c*) *Retests and Rejections.*—If upon testing a sample from a coil, reel or spool of wire, the results are found to be above the stated value for tensile strength or below the stated value for elongation, tests upon two additional samples will be made and the average of the three tests shall determine acceptance or rejection.

Conductivity. 9. The conductivity of the copper shall be not less than 98 per cent of the annealed copper standard. See Appendix I.

Tinning Tests. 10. (*a*) *Test.*—Each sample before stranding or insulating shall be given the following tests at the factory: The sample shall be thoroughly cleaned by immersing in redistilled petroleum ether, followed by immersion in 95-per-cent alcohol. The sample shall then be immersed in hydrochloric acid (sp. gr. 1.088) at a temperature of from 60 to 70° F. (15°.55–21°.10 C.) for one minute, washed in distilled water (the surplus water shaken off) and immersed in a solution of sodium sulfide for 30 seconds and again washed in water (the surplus water shaken off). The above operation shall be repeated four times for samples 0.02 in. in diameter or over, and three times for samples less than 0.02 in. in diameter. After the completion of the required number of cycles the samples shall not show any sign of blackening in the air which is perceptible to the eye.

(*b*) *Strength of Solution.*—The solution of sodium sulfide shall have sufficient strength to thoroughly blacken in 5 seconds a piece of untinned copper wire that has previously been cleaned in 95 per cent alcohol. The solution shall be prepared by thoroughly saturating (by boiling) a solution of sodium monosulfide with sulfur and shall have a specific gravity of 1.142 at 60° F. (15°.55 C.).

(*c*) *Number of Tests.*—Samples shall be taken in accordance with Section 16.

(*d*) *Retests and Rejections.*—If the specimen tested in accordance with Section 10 (*a*) shows any signs of blackening, two more specimens shall be tested. If one of these two additional specimens shows any signs of blackening, that coil or reel shall be rejected. If both specimens are free from any signs of blackening, the coil or reel shall be accepted. If more than

10 per cent of the samples in the entire order fail, all of the wire shall be rejected. If 10 per cent or less of the samples in the entire lot fail, each coil, reel or length may be tested and accepted or rejected upon the results of the individual tests.

III. PERMISSIBLE VARIATIONS IN DIMENSIONS.

Diameter and Area.

11. (*a*) *Permissible Variation.*—When the diameter of solid conductors and strands is specified, the permissible variation from the specified value shall not exceed 1 per cent under or 2 per cent over for wire 0.02 in. in diameter and larger, and 0.1 mil under for wire less than 0.02 in. in diameter.

When the area of cross-section is specified, the permissible variation shall not exceed 2 per cent under the specified value.

(*b*) *Method of Gaging Diameter.*—When wire is submitted in coils, each coil shall be gaged in three places, one near each end and one approximately at the middle. When wire is submitted on spools or reels, approximately 12 ft. of the wire shall be reeled off and the wire then gaged in six places between the second foot and the twelfth foot from the end.

(*c*) *Calculation of Area.*—The area of cross-section of wire shall be calculated from the average of the measurements of the diameter made in accordance with Section (*b*). The area of cross-section of cable shall be considered to be the sum of the cross-sectional areas of its component wires, when laid out straight and measured perpendicular to their axes.

(*d*) *Rejection.*—A coil or reel shall be rejected if the average diameter obtained from the measurements made in accordance with paragraph (*b*), or the area as calculated in accordance with paragraph (*c*), is not within the limits specified in paragraph (*a*).

A coil or reel shall be rejected if any individual measurement of diameter or of area of cross-section is not within twice the limits specified in paragraph (*a*).

(*B*) *Insulation.*

IV. CHEMICAL PROPERTIES AND TESTS.

Composition of Compound.

12. (*a*) *Composition.*—The insulation shall contain exclusively Hevea rubber which has not been previously used, waxy hydrocarbons consisting of ceresin or refined paraffin, sufficient

sulfur to properly vulcanize, and fillers which are entirely inorganic mineral matter containing no red lead, carbon or bitumen.

(*b*) *Requirements.*—The vulcanized compound shall conform on analysis to the following requirements expressed as percentages, by weight, of the whole sample:

	MAXIMUM.	MINIMUM.
Rubber	33	30
Waxy hydrocarbons	4	..
Free sulfur	0.7	..

Results shall be taken between the limits given in proportion to the percentage by weight of the rubber found.

The limits allowed for 30-per-cent rubber compound shall be as follows:

	MAXIMUM.	MINIMUM.
Saponifiable acetone extract	1.35	0.55
Unsaponifiable resins	0.45	....
Chloroform extract	0.90	....
Alcoholic potash extract	0.55	....
Total sulfur (see note)	2.10	....
Specific gravity	....	1.75

The limits allowed for 33-per-cent rubber compound shall be as follows:

	MAXIMUM.	MINIMUM.
Saponifiable acetone extract	1.50	0.60
Unsaponifiable resins	0.50	....
Chloroform extract	1.00	....
Alcoholic potash extract	0.60	....
Total sulfur (see note)	2.30	....
Specific gravity	....	1.67

The acetone solution shall not fluoresce.

The acetone extract (60 cc.) shall not be darker than a light straw color.

Hydrocarbons shall be solid, waxy and not darker than a light brown.

Chloroform extract (60 cc.) shall not be darker than a straw color.

Contamination of the compound, such as by the use of impregnated tapes, will not excuse the manufacturer from conforming to this specification.

NOTE.—The limit on total sulfur may be omitted at the option of the purchaser.

The compound shall be analyzed by the procedure recommended by the Joint Rubber Insulation Committee. See Appendix II.

(*c*) *Samples.*—Samples for chemical analysis shall be taken before the application of the braid and after the material has passed all physical and electrical tests. The purchaser may take samples in accordance with Section 16. The purchaser shall assure himself that all samples are free from contamination and change due to torch heating. Wherever practicable, samples shall be taken at a distance of at least 3 ft. from the end of the wire.

(*d*) *Retests and Rejections.*—The purchaser may make a chemical analysis on any one of the samples selected as above to determine if the compound meets the requirements of Section 12 (*b*). Failure of any one sample selected shall be sufficient cause to reject the wire which the sample represents, except in the case of failure to meet the requirements of either or both free sulfur and chloroform extract in accordance with Section 12 (*b*). In case of such failure the coil from which the sample was taken shall be rejected and two additional samples taken from the remainder of the order. The remainder of the order shall be accepted if both samples so selected shall meet the requirements for free sulfur or chloroform extract in accordance with Section 12 (*b*). The entire order shall be rejected if either sample fails to meet the requirements.

V. PHYSICAL PROPERTIES AND TESTS.

Physical Properties.

13. The test specimen shall have the following physical properties.

Tensile strength, minimum, lb. per sq. in.	1000
Set, maximum in 2 in., in.	$\frac{3}{8}$
Elongation, minimum before rupture, in.	2 to 9

Physical Tests.

14. (*a*) *Tension Test.*—A test specimen having a length of not less than 2 in., marked with bench marks 2 in. apart, shall be placed in the jaws of a test machine (maximum distance

between jaws holding the test specimen, 4 in.) and stretched at the rate of 20 in. per minute (jaw speed) until the specimen breaks. The test specimen shall break between the bench marks and the tensile strength shall be calculated upon the area of the original sample.

(*b*) *Set Test.*—A second test specimen having a length of not less than 6 in., marked with bench marks 2 in. apart, shall be placed in the jaws of a test machine (maximum distance between jaws holding test specimen, 4 in.) and stretched at a rate of 20 in. per minute until the bench marks are 6 in. apart. After the termination of this stretch, the test specimen shall be released within 5 seconds and the set determined 1 minute after the beginning of release.

(*c*) *Elongation Test.*—After the determination of the set in accordance with paragraph (*b*), the *same* specimen shall be placed in the jaws of a test machine (maximum distance between jaws holding test specimen, 4 in.) and stretched at the rate of 20 in. per minute (jaw speed) until the specimen breaks. The test specimen shall break between the bench marks.

(*d*) *Accuracy of Machine.*—The test machine shall be accurate within 1 per cent of the breaking load.

(*e*) *Jaws.*—The jaws of the machine shall be of an approved type.

(*f*) *Temperature.*—All physical tests shall be made at a room temperature of from 65 to 85° F. (18°.33 to 29°.44 C.) inclusive, and the test specimen shall have been kept at the room temperature not less than 30 minutes prior to the tests.

Test Specimen.

15. (*a*) *Test Specimen.*—The test specimen may be the entire section of the insulation in the case of small wires, or in the case of a large wire, a segment of a section, cut with a sharp knife held tangentially to the conductor. The test specimen shall be as free as possible from surface incisions and imperfections.

(*b*) *Buffing.*—In event of any irregularities on the surface of the test specimen, it shall be made smooth and of uniform thickness within 5 per cent of the original thickness by buffing, except when large strands are used, in which case the rubber sample shall be buffed sufficiently to remove all corrugations.

(*c*) *Limits.*—There shall be no limit to the cross-section of the test specimen, except as restricted by the capacity of the test machine.

(*d*) *Calculation of Area.*—Calculation of the area of test specimen shall be made as follows:

(1) When the total cross-section of the insulation is used, the area shall be calculated as the area of the circle whose diameter is the minimum average outside diameter of the insulation minus the area of the conductor. The area of a stranded conductor shall be figured from its maximum diameter.

(2) When a slice cut from the wire by a knife held tangent to the wire is used, and the slice so cut has the cross-section of a segment of a circle, the area shall be calculated as that of the segment of a circle whose diameter is that of the insulation. The height of the segment is the wall of insulation on the side from which the slice is taken. (The values are most easily obtained from a table giving the areas of segments of a unit circle for the ratio of the height of the segment to the diameter of the circle.)

(3) When the cross-section of the slice is not a segment of a circle, the area shall be calculated from a direct measurement of the volume or from the specific gravity and the weight of a known length of a uniform cross-section.

(4) When a portion of a sector of a circle has to be taken (as in the case of large conductors with thin walls) the area shall be calculated as the thickness times the width. (This applies either to a straight test piece or one stamped out with a die, and assumes that corrugations have been removed by buffing.)

(5) When a portion of a sector of a circle has to be taken on large conductors with thick walls the area shall be calculated as the proportional part of the area of the total cross-section.

Number of Physical Test Specimens.

16. (*a*) *Less than 500 Feet.*—When an order calls for less than 500 ft., physical tests shall be waived.

(*b*) *Over 500 Feet.*—When an order calls for 500 ft. or more and is made into one or more coils, reels or lengths, samples shall be taken from 10 per cent of the coils, reels or lengths, but in all cases there shall be one sample taken.

Retests and Rejections, Physical Tests.

17. (*a*) *Retests.*—If a specimen fails to pass in either of the three tests prescribed in Section 14, two more specimens shall be taken from the same sample and the average of the results shall determine whether or not the sample complies with the requirements.

(*b*) *Rejections.*—When ten or more samples are selected in any inspection lot, all coils, reels or lengths shall be rejected if more than 10 per cent of the samples fail. If 10 per cent or less fail, each coil, reel or length may be tested and shall be accepted or rejected upon the result of individual test. Where the number of samples selected in any inspection lot is less than ten, all coils, reels or lengths shall be rejected if more than 20 per cent of the samples fail. If 20 per cent or less fail, each coil, reel or length may be tested and shall be accepted or rejected upon the result of individual test.

TABLE III.—VALUES OF TEST POTENTIALS, IN KILOVOLTS

(ASSOCIATION OF RAILWAY ELECTRICAL ENGINEERS.)

Size of Conductors.	Thickness of Insulation, 64ths in.							
	2	3	4	5	6	7	8	10
18 A. w. g. or B. & S.	1.0	2.5	4.5	5.5	6.5	7.5	8.5	10.5
16 " "	1.0	2.5	4.5	5.5	6.5	7.5	8.5	10.5
14 " "	...	2.5	5.0	6.0	7.0	8.0	9.0	11.0
12 " "	...	2.5	5.0	6.0	7.5	8.5	9.5	11.5
10 " "	...	3.0	5.0	6.5	8.0	8.5	10.0	12.0
8 " "	...	3.0	5.0	7.0	8.0	9.5	11.0	13.0
6 " "	...	...	5.0	6.5	8.5	10.0	11.5	14.0
4 " "	...	...	4.5	6.5	8.5	10.0	11.5	14.5
2 " "	...	...	4.0	6.0	8.0	10.0	12.0	15.0
0 " "	...	...	...	5.5	8.0	10.0	12.0	15.5
00 " "	...	...	...	5.0	7.5	9.5	11.5	15.5
000 " "	...	...	...	5.0	7.5	9.5	11.5	15.5
0000 " "	...	...	...	4.5	7.0	9.0	11.5	15.5
250 000 C. M.	...	...	...	4.0	6.5	9.0	11.0	15.5
500 000 "	...	...	...	2.5	5.0	7.5	10.0	14.5
750 000 "	...	...	...	...	...	6.5	9.0	14.0
1 000 000 "	...	...	...	...	...	5.5	8.0	13.0
1 250 000 "	...	...	...	...	...	...	7.5	12.5
1 500 000 "	...	...	...	...	...	...	7.0	12.0
1 750 000 "	...	...	...	...	...	...	6.5	11.5
2 000 000 "	...	...	...	...	...	...	5.0	10.5

VI. ELECTRICAL PROPERTIES AND TESTS.

Electrical Properties.

18. (*a*) *Place.*—All electrical tests shall be made at the factory.

(*b*) *Requirements.*—Every coil, reel or length of wire, after vulcanization and before the application of paraffin or

TABLE IV.—INSULATION RESISTANCE, IN MEGOHM-MILES AT 60° F.[1]

(ASSOCIATION OF RAILWAY ELECTRICAL ENGINEERS.)

Size of Conductors.	Thickness of Insulation, 64ths in.																
	2	3	4	5	6	7	8	10	12	14	16	18	20	22	24	26	28
18 A. w. g. or B. & S.	1600	2050	2450	2800	3000	3200	3400	3750	4050	4300	4500	4700	4900	5000	5150	5300	5400
16 " "	1400	1800	2150	2400	2650	2850	3050	3400	3650	3950	4150	4350	4500	4650	4800	4900	5050
14 " "	....	1530	1850	2150	2350	2550	2650	3050	3350	3550	3800	3950	4100	4300	4400	4550	4650
12 " "	....	1350	1600	1850	2050	2250	2400	2750	3000	3250	3400	3600	3750	3900	4050	4150	4300
10 " "	....	1150	1350	1600	1800	2000	2150	2400	2650	2900	3100	3250	3400	3550	3700	3800	3900
8 " "	....	850	1050	1250	1450	1650	1750	2050	2200	2400	2600	2750	2900	3050	3150	3250	3350
6 " "	....	....	850	1050	1200	1350	1450	1750	1950	2100	2300	2450	2550	2700	2800	2900	3000
4 " "	....	....	750	850	1000	1150	1250	1450	1650	1850	2000	2150	2250	2400	2500	2600	2700
2 " "	....	....	650	750	850	950	1050	1250	1450	1600	1700	1850	1950	2100	2200	2300	2400
1 " "	....	....	600	650	750	850	1000	1150	1350	1450	1600	1750	1850	1950	2050	2150	2250
0 " "	....	....	....	600	700	800	950	1050	1200	1350	1500	1600	1700	1800	1900	2000	....
00 " "	....	....	....	550	650	750	850	950	1050	1250	1350	1500	1600	1700	1800	....	....
000 " "	....	....	....	500	600	650	750	850	1000	1150	1250	1350	1450	1550	....	....	....
0000 " "	....	....	....	450	550	600	650	800	950	1050	1150	1250	1350	1450	....	....	....
250 000 C. M.	....	....	....	400	475	575	625	725	875	1000	1100	1200	1275	....	....	....	....
350 000 "	....	....	....	350	425	475	525	675	775	850	950	1050	1125	....	....	....	....
500 000 "	....	....	....	300	375	400	475	575	675	750	850	900	....	....	....	....	....
750 000 "	....	....	....	....	....	325	400	475	525	625	700	775	....	....	....	....	....
1 000 000 "	....	....	....	....	....	300	325	400	475	550	625	....	....	....	....	....	....
1 250 000 "	....	....	....	....	....	....	325	375	425	500	575	....	....	....	....	....	....
1 500 000 "	....	....	....	....	....	....	300	325	400	475	....	....	....	....	....	....	....
1 750 000 "	....	....	....	....	....	....	275	300	375	450	....	....	....	....	....	....	....
2 000 000 "	....	....	....	....	....	....	200	275	325	425	....	....	....	....	....	....	....

NOTE.—For intermediate sizes, use values of next larger size.

[1] This table is based on the constant 4000 in the following formula:

$R = K \log \frac{D}{d}$ where R = resistance in megohms, K = Constant, D = diameter over insulation d = diameter over conductor.

any covering other than tape or braid used in vulcanization, shall successfully withstand a high voltage test as specified in Table III, and shall have an insulation resistance not less than that specified in Table IV. These tests shall be made after not less than 18 hours immersion in water, and while still immersed.

High Voltage Test.

19. The test voltage shall be applied for 5 minutes. The test shall be made in accordance with the Standardization Rules of the American Institute of Electrical Engineers. See Appendix I.

TABLE V.

(TESTS SHALL BE MADE AT TEMPERATURES WITHIN THE SCOPE OF THIS TABLE.)

Temperature.		Coefficient.	Temperature.		Coefficient.
Deg. Fahr.	Deg. Cent.		Deg. Fahr.	Deg. Cent.	
46	7.8	0.694	61	16.1	1.026
47	8.3	0.709	62	16.7	1.053
48	8.9	0.729	63	17.2	1.081
49	9.4	0.746	64	17.8	1.109
50	10.0	0.769	65	18.3	1.138
51	10.6	0.787	66	18.9	1.169
52	11.1	0.806	67	19.4	1.200
53	11.7	0.833	68	20.0	1.231
54	12.2	0.854	69	20.6	1.264
55	12.8	0.877	70	21.1	1.297
56	13.3	0.900	71	21.7	1.331
57	13.9	0.917	72	22.2	1.366
58	14.4	0.943	73	22.8	1.402
59	15.0	0.970	74	23.3	1.438
60	15.6	1.000	75	23.9	1.477

Insulation Resistance.

20. (*a*) *Method.*—This test shall be made in accordance with the Standardization Rules of the American Institute of Electrical Engineers. See Appendix I.

(*b*) *Temperature Coefficient.*—The insulation resistance (megohms) shall be reduced to that at 60° F. (15°.55 C.) by multiplying by the coefficient in Table V corresponding to the temperature at which test is made.

Rejections, Electrical Test.

21. Every coil, reel or length shall be rejected if it fails to comply with the electrical requirements herein specified.

(*C*) *Inspection.*

Inspection.

22. (*a*) The manufacturer shall notify the purchaser sufficiently in advance of the completion of the wire or cable to permit of arrangement for the inspection.

(*b*) The inspector representing the purchaser shall have free entry at all times, while work on the contract of the purchaser is being performed, to all parts of the manufacturer's works which concern the manufacture of the wire ordered, except compounding room. The manufacturer shall afford the inspector, free of cost, all reasonable facilities to satisfy him that the wire is being furnished in accordance with these specifications. Tests and inspection shall be made prior to shipment, at the place of manufacture.

(*c*) The purchaser may make the tests to govern the acceptance or rejection of the wire in his own laboratory or elsewhere. Such tests, however, shall be made at the expense of the purchaser.

Rehearing.

23. Samples of rejected material shall be preserved for two weeks from date of test report. In case of dissatisfaction with the results of test, the manufacturer may make claim for a rehearing within that time. Sealed duplicate samples may be retained by the manufacturer at his option.

APPENDIX I.

EXTRACTS FROM STANDARDIZATION RULES OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

(Edition July 1, 1915.)

Conductivity of Copper.

1. The following shall be taken as normal values for standard annealed copper:

(*a*) At a temperature of 20° C. the resistance of a wire of standard annealed copper 1 m. in length and of a uniform section of 1 sq. mm. is 1/58 ohm = 0.017241 ohm.

(*b*) At a temperature of 20° C. the density of standard annealed copper is 8.89 g. per cubic centimeter.

(*c*) At a temperature of 20° C. the "constant mass" temperature coefficient of resistance of standard annealed copper, measured between two potential points rigidly fixed to the wire, is 0.00393 = 1/254.45 . . . per degree Centigrade.

(*d*) As a consequence, it follows from (*a*) and (*b*) that at a temperature of 20° C. the resistance of a wire of standard annealed copper of uniform section, 1 m. in length and weighing 1 g. is $(\frac{1}{58}) \times 8.89 = 0.15328$ ohm.

High-Voltage Test.

(*a*) *Frequency.*

2. The frequency of the test voltage shall not exceed 100 cycles per second, and should approximate as closely as possible to a sine wave. The source of energy should be of ample capacity.

(*b*) *Rate of Increase of Voltage.*

3. The initially-applied voltage shall not be greater than the working voltage and the rate of increase shall not be over 100 per cent in 10 seconds.

Insulation Resistance Test.

4. The apparent insulation resistance should be measured after the dielectric-strength test, measuring the leakage current after a one-minute electrification, with a continuous e.m.f. of from 100 to 500 volts, the conductor being maintained positive in the water.

APPENDIX II.

JOINT RUBBER INSULATION COMMITTEE PROCEDURE FOR THE ANALYSIS OF RUBBER COMPOUND.

Object of the Analysis.

1. The object of this procedure of analysis is to determine whether rubber compounds comply chemically with the accompanying specification which is intended to secure compounds containing 30 per cent of the best Hevea rubber, and mineral fillers.

Outline of Procedure.

2. The general procedure is shown in Fig. 1.

General.

3. Make the analysis upon the insulation after vulcanization and, whenever possible, before the saturation of the braid. Wipe the insulation thoroughly with a damp cloth to remove any adhering material, but do not remove waxy hydrocarbons from the surface.

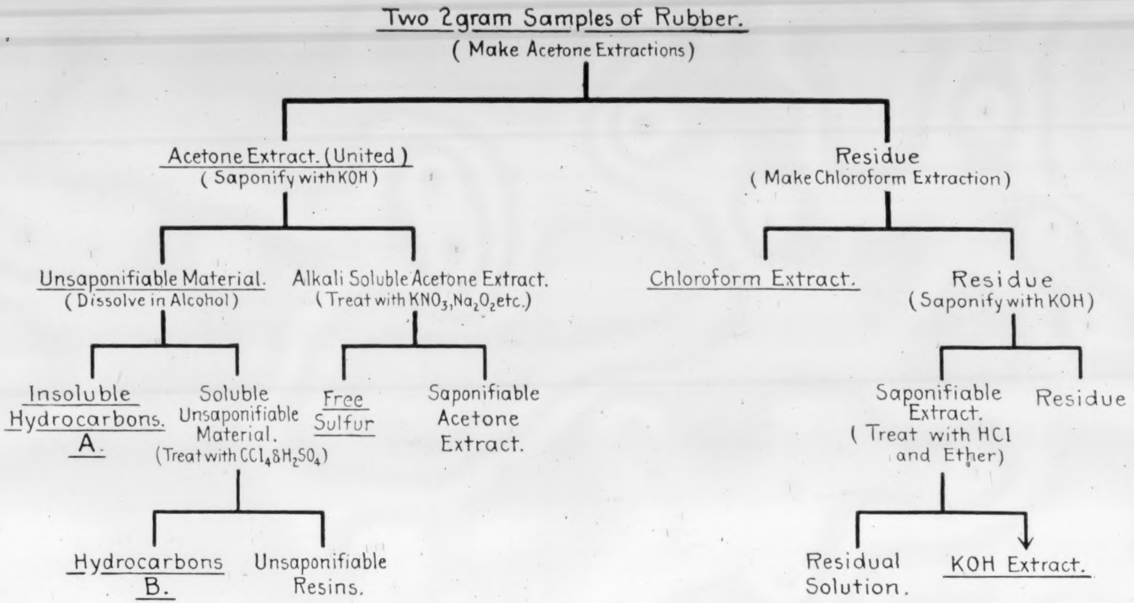
4. If, however, a saturated braided sample must be used, remove the braid and sandpaper the insulation to a depth of at least 0.005 in. and wipe with a damp cloth. In such cases report the condition of the sample.

5. Perform all determinations in duplicate and take the average value arbitrarily as the true value. Duplicate determinations must check within the limits specified.

6. Make blanks on all determinations and deduct the results accordingly.

Sample.

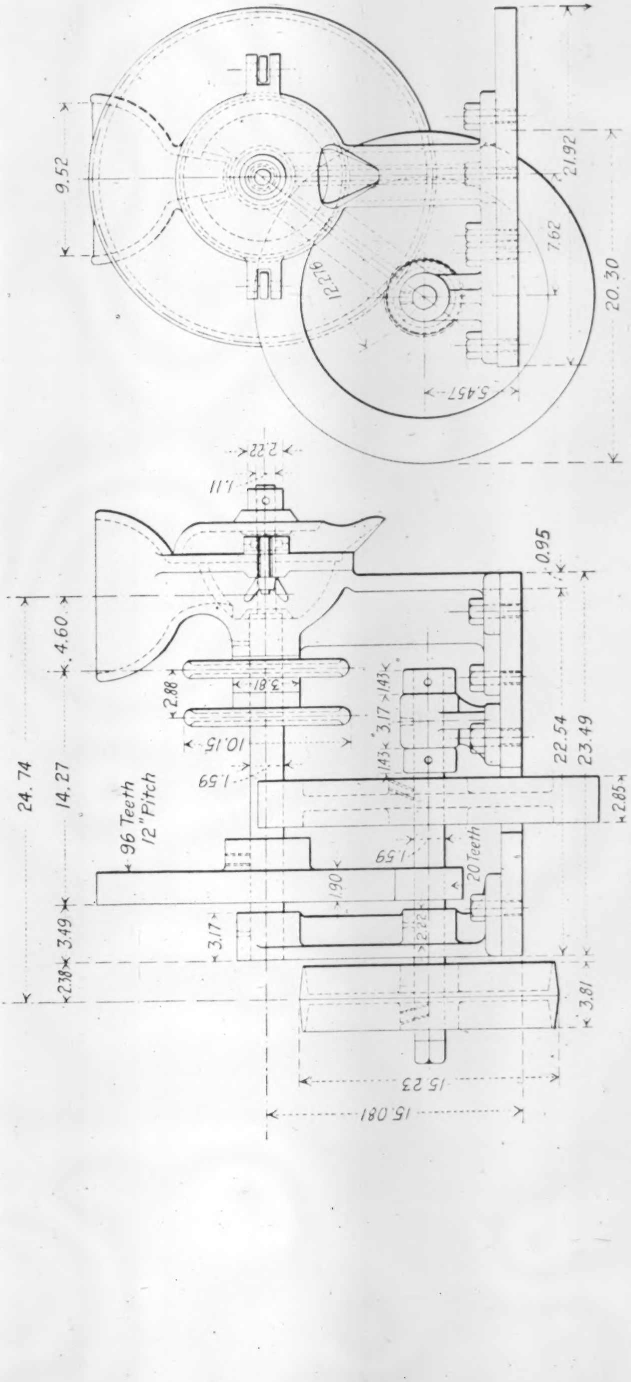
7. Remove the insulation entirely from sufficient wire to give a sample weighing about 25 g. Cut this into small strips and grind slowly in either a No. 0 Enterprise coffee mill or a


Two 2gram Samples of Rubber.
(Make Acetone Extractions)
Acetone Extract. (United)
(Saponify with KOH)
Residue
(Make Chloroform Extraction)
Unsaponifiable Material.
(Dissolve in Alcohol)
Alkali Soluble Acetone Extract.
(Treat with KNO3, Na2O2 etc.)
Chloroform Extract.
Residue
(Saponify with KOH)
Insoluble Hydrocarbons. A.
Soluble Unsaponifiable Material.
(Treat with CCl4 & H2SO4)
Free Sulfur
Saponifiable Acetone Extract.
Saponifiable Extract.
(Treat with HCl and Ether)
Residue
Hydrocarbons B.
Unsaponifiable Resins.
Residual Solution.
KOH Extract.

Total Waxy Hydrocarbons = A + B.

Weigh Substances with Names Underlined; Other Substances by Difference.

FIG. 1.—Outline of Method For Rubber Analysis.
(Exclusive of Fillers and Total Sulfur Determinations.)

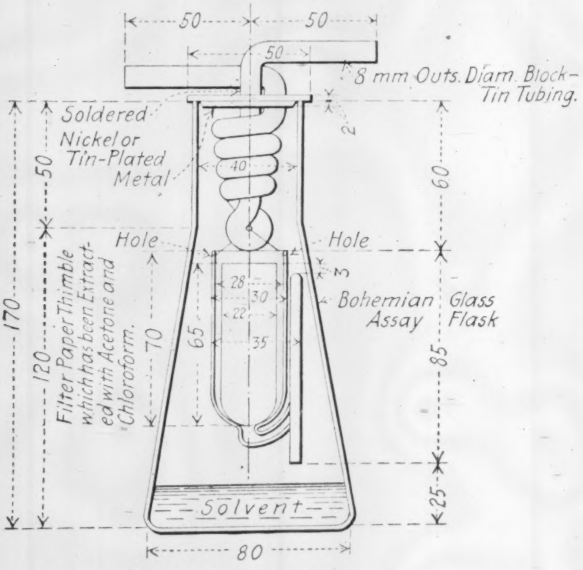

9.52
21.92
7.62
12.216
20.30
5.457
2.22
1.11
0.95
4.60
24.74
14.27
96 Teeth
12" Pitch
2.88
3.81
10.15
1.59
1.43
3.17
1.43
22.54
23.49
2.85
1.59
20 Teeth
1.90
3.17
2.22
3.49
2.38
3.81
15.23
15.081

(All Dimensions in Centimeters.)

Grinding Plates of the No. 0 Enterprise Coffee Mill to be Used.

FIG. 2.—Rubber Grinder

mill such as shown by Fig. 2. Adjust the grinder so that not more than 20 per cent will pass through a 40-mesh sieve. Sift all the material through a 20-mesh sieve, regrinding what is retained on the sieve until the entire sample has passed through. The wires of the sieves shall be evenly spaced in both directions and shall be of 0.016 and 0.010 in. diameter in the 20 and 40-mesh sieves respectively. Remove with a strong magnet any metal that may have come from the grinder and thoroughly mix the sample.


50
50
50
8 mm Outs. Diam. Block-Tin Tubing.
2
Soldered Nickel or Tin-Plated Metal
40
50
60
Hole
Hole
3
28
30
22
35
65
70
120
170
Filter Paper Thimble which has been Extracted with Acetone and Chloroform.
Bohemian Assay Glass Flask
85
25
Solvent
80

(All dimensions in millimeters.)

FIG. 3.—Extraction Apparatus.

EXTRACTION APPARATUS.

8. The extraction apparatus shall conform to Fig. 3. It shall be heated so that the period of filling an empty syphon cup with acetone and completely emptying it, will be between 2½ and 3½ minutes.

PREPARATION OF REAGENTS.

Acetone. 9. Acetone shall be freshly distilled over anhydrous K_2CO_3, using the fraction 56–57° C.

KOH.

10. Alcoholic KOH solution shall be of normal strength and shall be made freshly by dissolving the proper amount of KOH (purified by alcohol) in 95 per cent alcohol which has previously been distilled over KOH. The solution shall be allowed to stand for 24 hours and only the clear liquid used.

Ether.

11. Ether shall be washed with three successive portions of distilled water and distilled, using the fraction 34–36° C.

Chloroform.

12. Chloroform shall be pure and freshly distilled.

Carbon Tetrachloride.

13. Carbon tetrachloride shall be pure and freshly distilled.

14. Reagents not otherwise specified shall be c.p. Water shall be distilled.

ACETONE EXTRACT.

Acetone Extract.

15. Extract continuously with 60 cc. of acetone for 8 hours, two 2-g. samples that have been prepared within 24 hours. Unite the extracts in a weighed flask, using hot chloroform to rinse the flasks. Distill off the reagents and dry the flask and contents for 4 hours at 95–100° C. Desiccate until cool and weigh. Continue to dry for 2-hour periods until constant weight is obtained. In drying, place the flask on its side but at a sufficient angle from the horizontal so that the extract does not appreciably run down the side of the flask.

UNSAPONIFIABLE MATERIAL.

Unsaponifiable Matter.

16. Add to the acetone extract 50 cc. of alcoholic KOH solution, boil under a reflux condenser for 2 hours, and evaporate to dryness, removing all alcohol. Add 10 cc. of water and 20 cc. of ether; heat until the wax, etc., are in solution, cool, transfer to a separatory funnel, wash out the flask with warm water and then cool, finally with two 20-cc. portions of ether. The water volume should be 100 cc. and the ether at least 40 cc. Shake vigorously for 2 minutes, and allow the solutions to separate thoroughly. Draw off the aqueous solution into a second funnel, leaving in the first funnel the ethereal solution and any flocculent material that may be present. Again rinse the flask with 20 cc. of ether and add it to the aqueous solution; shake vigorously for 2 minutes, and when separated draw off the aqueous solution and unite in the first funnel the ethereal solutions and any flocculent material. Repeat, shaking with 20-cc.

portions of ether until the extraction is complete, using at least 120 cc. of ether. Wash the flask and the funnel, from which the ethereal solution has been taken, with water, until they are free from alkali, subsequently using this wash water to wash the ethereal solution. Continue washing with water until it has been washed twice after it shows no alkaline reaction. Retain with the ethereal solution any flocculent material. Filter the ethereal solution from the flocculent material, through a small pellet of extracted cotton, into a weighed flask, washing first with ether and subsequently with hot chloroform, using this to rinse the original flask and both separatory funnels. Evaporate the solvents and dry the extract to constant weight at 95 to 100° C.; desiccate until cool and weight.

HYDROCARBONS A.

Hydrocarbons A.

17. Add 50 cc. absolute alcohol to the unsaponifiable material and warm until solution is as complete as possible. Cool the solution to −4 or −5° C. and maintain at this temperature for 1 hour by packing the flask in a mixture of ice and salt. Filter out the waxy hydrocarbons, using a funnel packed with ice and salt, and apply suction if necessary. Wash the flask and filter with about 25 cc. of 95 per cent alcohol, which has been previously cooled in the same temperature. Catch the filtrate in a flask which is afterwards cooled to −4 or −5° C. to make sure that all possible waxy hydrocarbons have been removed, and refilter if necessary. Dissolve the residue on the filter paper with hot chloroform, into the original flask. Evaporate the chloroform and dry the flask to constant weight at 95 to 100° C. Cool in a desiccator and weigh.

HYDROCARBONS B.

Hydrocarbons B.

18. Evaporate the alcohol from the flask containing the alcoholic soluble unsaponifiable material, add 25 cc. carbon tetrachloride and transfer to a separatory funnel. Shake with concentrated H_2SO_4, drain off the discolored acid and repeat with fresh portions of acid until there is no longer any discoloration. After drawing off all the acid, wash the carbon tetrachloride solution with repeated portions of water until all traces of acid

are removed. Transfer the carbon tetrachloride solution to a weighed flask; evaporate off the solvent and dry the flask to constant weight at 95 to 100° C. Cool in a desiccator and weigh.

FREE SULFUR.

Free Sulfur.

19. Add 2 g. KNO_3 to the aqueous solution and washings from the ethereal separation of the unsaponified material. Evaporate to dryness in a silver or nickel dish and heat to quiet fusion, avoiding contamination with sulfur fumes. Transfer with water to an evaporating dish, acidify with HCl, evaporate to dryness, and dehydrate silica. Add 2 cc. concentrated HCl, take up in water, filter and wash, making a volume of 200 cc. Heat to boiling and add slowly a slight excess of hot 10 per cent $BaCl_2$ solution. Allow to stand over night, filter, wash, ignite, weigh the $BaSO_4$ and calculate the sulfur.

DEFINITION OF TERMS DESCRIBING COMPONENTS OF ACETONE EXTRACT.

Organic Extract.

20. The difference between the Acetone Extract and the Free Sulfur shall be called the Organic Extract.

Saponifiable Acetone Extract.

21. The difference between the Organic Extract and the Unsaponifiable Material shall be called the Saponifiable Acetone Extract.

Waxy Hydrocarbon.

22. The sum of the Hydrocarbons A and B shall be called the total Waxy Hydrocarbons.

Unsaponfiable Resins.

23. The difference between the Unsaponifiable Material and the Waxy Hydrocarbons shall be called Unsaponifiable Resins.

CHLOROFORM EXTRACT.

Chloroform Extract.

24. Extract continuously the residues from both of the acetone extractions (without necessarily removing the acetone that may be on them) for 4 hours with 60 cc. of chloroform, unite the extractions in a weighed flask, using hot chloroform to rinse the flasks. Distill off the solvent and dry the flask and contents for 2 hours at 95 to 100° C. Desiccate until cool and weigh. Continue to dry for 1-hour periods until constant weight is obtained. In drying, place the flask on its side but at a sufficient angle from the horizontal so that the extract does

not appreciably run down the side of the flask. (If it is needful to wait after the acetone extraction, before starting the chloroform extraction, the sample must be kept in a vacuum of at least 50 mm. of mercury.)

ALCOHOLIC-POTASH EXTRACT.

Alcoholic KOH Extract.

25. Dry the residue from the chloroform extraction at 50 to 60° C. until odor of chloroform can no longer be detected, unite residues from the two 2-g. samples in a 200-cc. Erlenmeyer flask. Add 100 cc. alcoholic KOH solution and boil for 4 hours under a reflux condenser. Filter the solution by decantation through an 11-cc. hardened filter paper into a beaker and wash twice, using each time 25 cc. hot absolute alcohol and then wash thoroughly with hot water. Wash any rubber on the filter paper back into the original flask and reserve this for the determination of the rubber hydrocarbons. Evaporate the solution to approximate dryness, take up in warm water and transfer to a separatory funnel. Acidify with 15 cc. of 5 normal HCl, using this to rinse the beaker. Add sufficient water to make the bulk of the solution 100 cc. When cool add 40 cc. of ether, using it to rinse the beaker in 20-cc. portions. Shake the aqueous and ethereal solutions thoroughly. After complete separation, draw off the aqueous solution and treat in another separatory funnel, with a fresh 20-cc. portion of ether. Continue to shake the aqueous solution with fresh portions of ether until a colorless portion has been obtained, then shake out twice more. Unite the ethereal solutions and wash with successive additions of water, continuing twice after the water shows no acid reaction. Filter through a plug of extracted cotton into a tared flask, wash the filter and funnel with ether, evaporate the ether without boiling and dry the residue to constant weight at 95 to 100° C. Cool in a desiccator and weigh.

RUBBER HYDROCARBONS.

Rubber Hydrocarbons.

26. Add to the flask containing the rubber residue from the alcoholic KOH extraction, sufficient water to make the total volume of the solution 125 cc. and then add 25 cc. concentrated HCl. Heat for an hour at 97 to 100° C. Decant the supernatant liquid through a hardened filter paper on a Buch-

ner funnel 7 cm. diameter, using suction; wash the residue with 25 cc. hot water and decant. (While a Buchner funnel is recommended, it is permissible to use an 11-cm. hardened filter paper with platinum cone, in a 60-deg. funnel.) Perform this entire treatment with water and HCl three times and save the first and second decantations for the "organic matter" test described in Section 33. The rubber at this stage should be white and practically free from black specks of undissolved fillers; if not, continue the acid treatment until the black specks disappear. (If carbon is present, all the particles of rubber will be grayish, bluish, or black, depending on the form and quantity of carbon used. Black specks in light particles of rubber usually indicate the presence of lead sulfide which must be removed to prevent the formation of lead sulfate on igniting the residue *C*.) Add 150 cc. of hot water to the flask and let stand on a steam bath or hot plate for half an hour and decant through the filter paper, repeating until washings are free from chlorides. (See Section 33.) Transfer all the rubber in the flask to the filter paper and dry as much as possible by suction. Wash the rubber with 50 cc. of 95-per-cent alcohol, using suction. Transfer the entire residue to a weighing bottle. Dry at 95 to 100° C. for an hour, cool in a vacuum desiccator under reduced pressure and weigh. Dry for a half hour, cool and weigh, repeating this process until either constant weight is reached or the weight starts to increase. Let this weight be represented by *C*. Determine the ash (*E*) on a portion (*D*) of this residue (*C*) and sulfur (*H*) on the remaining portion (*G*). Also determine the sulfur (*F*) on the ash (*E*). Perform the ash determination as described under ash in Rubber Residue and the sulfur determinations as described under Total Sulfur. Then,

$$\text{Rubber hydrocarbons} = 100\,\frac{C}{4}\left(1 - \frac{H}{C} - \frac{E-F}{D}\right)$$

expressed as a percentage of the total sample.

ASH IN RUBBER RESIDUE.

27. Place about 0.5 g. (*D*) of residue *C* into a weighed porcelain crucible and heat gently, gradually driving off the **Ash in Rubber Residue.**

volatile matter. When the crucible has ceased to smoke, raise the temperature gradually to between 450 and 500° C., until all organic matter has been burned away, which is usually indicated by the ash becoming white. (an electric muffle furnace with pyrometer is recommended for this purpose.) Cool in a desiccator and weigh, the weight of ash being represented by *E* in the formula for rubber hydrocarbons. Make sulfur test on ash by the method described under Total Sulfur. If, however, the ash (*E*) is not over 0.08 *D*, the determination of sulfur in the ash may be omitted, and *F* assumed to be zero.

TOTAL SULFUR.

Total Sulfur.

28. Mix a 0.5-g. sample with 4 g. of Na_2O_2 and 6 g. of K_2CO_3 in a dry 15-cc. iron crucible. Cover and heat gradually until the mixture fuses, proceeding cautiously, as rapid heating will cause an explosion, and then bring to quiet fusion for 15 to 20 minutes. Apply the heat so as to avoid contamination with sulfur fumes. Rotate the crucible while the melt solidifies. When cool, put crucible and cover into a casserole containing 200 cc. of water; add 5 to 10 cc. of bromine water and boil until the melt is dissolved. Allow the precipitate to settle, decant the liquid through a thick filter and wash the residue with hot water. Acidify the filtrate with HCl, evaporate to dryness and dehydrate silica; add 2 cc. of concentrated HCl, take up in water, filter and wash, making the total volume about 100 cc. Heat to boiling and add slowly a slight excess of hot 10-per-cent $BaCl_2$ solution. Allow to stand over night, filter, wash, ignite, weigh the $BaSO_4$ and calculate to sulfur.

SPECIFIC GRAVITY.

Specific Gravity.

29. The specific gravity shall be the ratio of the weight of a given volume of the rubber to the weight of an equal volume of water, both at 20° C. Cut strips of the largest applicable size from the conductor and use about 5 g. for the sample. Determine the specific gravity in the usual manner by means of a specific gravity bottle. Care must be taken that no air bubbles adhere to the sample.

CHECKS.

Checks.

30. Specific gravity determinations shall check within 0.01. The other duplicate determinations shall check within the following limits expressed as percentages of the original sample.

DETERMINATION.	CHECK.
Acetone extract	0.10
Saponifiable acetone extract	0.10
Unsaponifiable resins	0.10
Waxy hydrocarbons	0.10
Free sulfur	0.05
Chloroform extract	0.10
Alcoholic potash extract	0.10
Rubber hydrocarbons	0.20
Total sulfur	0.10

INTERPRETATION.

Interpretation.

31. The rubber shall be considered to be the sum of the rubber hydrocarbons, saponifiable acetone extract, unsaponifiable resins and chloroform and alcoholic potash extracts, expressed as percentages. If the chloroform extract is over 3.0 per cent of the rubber so calculated, subtract the excess from the rubber. If the KOH extract is over 1.8 per cent of the rubber as first calculated, subtract this excess also from the rubber.

RED LEAD.

Red Lead.

32. Dissolve 1 g. of the sample in 75 cc. of xylol at a temperature of about 100° C. When the rubber is dissolved, the absence of any red particles indicates the absence of red lead. If red particles are present, filter the solution into a Gooch crucible and wash thoroughly with benzol, acetone and alcohol successively. Remove the felt and residue to a distilling flask, add HCl, and distill over the chlorine liberated by the lead peroxide, absorbing the gas in a solution of KI and starch. Not more than 0.1 cc. of N/10 thiosulfate shall be required to titrate the iodine liberated.

ORGANIC FILLERS.

Organic Filler

33. Transfer the first and second decantations of the HCl solutions to a carefully cleaned porcelain dish and add 20 cc.

concentrated H_2SO_4. Place dish on steam bath or hot plate to drive off water and HCl. A pronounced charring of the residue indicates the presence of organic matter soluble in water or hydrolyzed by HCl. Examine filter paper and rubber while decanting acid solution and washing free of chlorides. Some types of organic fillers not removed by water and HCl, would be plainly visible at this point. Place a small portion of residue *C* under a microscope and examine for fibrous and other characteristic organic material. If organic fillers are indicated and not clearly proven by this test, place 1 g. of the original sample in a beaker, add 50 cc. of xylol and heat on hot plate until the rubber is dissolved. Decant xylol solution and wash residue with ether several times by decantation. Dry residue and examine under the microscope.

STATEMENT OF RESULTS.

Statement of Results.

34. The results of the analysis shall be stated in the following form:

	PER CENT.
Acetone extract	....
Saponifiable acetone extract	....
Unsaponifiable resins	....
Waxy hydrocarbons	....
Free sulfur	....
Chloroform extract	....
Alcoholic potash extract	....
Total sulfur	....
Rubber	....
Color of acetone extract (60 cc. vol.)	....
Fluorescence in acetone extract solution (present or absent)	....
Hydrocarbons A (consistency and color)	....
Hydrocarbons B (solid or liquid)	....
Color of chloroform extract (60 cc. vol.)	....
Carbon (present or absent)	....
Red lead (present or absent)	....
Specific gravity	....

AMERICAN SOCIETY FOR TESTING MATERIALS
PHILADELPHIA, PA., U. S. A.
AFFILIATED WITH THE
INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE SPECIFICATIONS
FOR
ADHESIVE INSULATING TAPE.[1]

Serial Designation: D 69 – 20 T.

These specifications are issued under the fixed designation D 69; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1920.

Material Covered.

1. These specifications cover a friction tape composed of cotton sheeting impregnated with an adhesive insulating compound.

I. MANUFACTURE.

Cotton Sheeting.

2. The cotton sheeting layer shall be made from a sheeting evenly and firmly woven from good cotton, and as free from unsightly defects, dirt, knots, lumps, and irregularities of twist as is consistent with the best manufacturing practice. The threads shall run in straight lines without waving, so as to reduce to a minimum the raveling of the cloth when cut into tape.

Frictioning Compound.

3. The frictioning compound shall be an adhesive and insulating compound practically free from free sulfur (not over 0.05 per cent) or other substances which would have a deteriorating effect on copper or other metals or on the fabric.

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[1] Criticisms of these Tentative Specifications are solicited and should be directed, preferably before January 1, 1921, to Mr. F. M. Farmer, Chairman of Committee D-11 on Rubber Products, Electrical Testing Laboratories, Eightieth St. and East End Ave., New York City.

Impregnation of Compound. 4. The fabric shall be thoroughly impregnated and evenly covered on both sides with the frictioning compound.

Thickness. 5. The thickness of the tape shall be not less than 0.013 nor more than 0.017 in.; when measured with a rubber spring micrometer with 0.4-in. diameter foot.

Firmness of Compound. 6. The compound shall adhere firmly to the fabric and shall not pull away from the fabric so as to leave bare spots when adjacent thicknesses of the tape are separated.

II. PHYSICAL PROPERTIES AND TESTS.

Pin Holes. 7. When the tape is held before a strong light, the number of pin holes noted per linear yard of tape, $\frac{3}{4}$ in. wide, shall not exceed two.

Tensile Strength. 8. The tensile strength per $\frac{3}{4}$-in. width shall be not less than 30 lb. The initial distance between the jaws of the testing machine shall be 12 in., and the rate of separation of the jaws shall be 20 in. per minute.

Discoloration. 9. When wrapped on a clean, smooth copper rod and baked at 100° C. for 16 hours, the compound shall not discolor the copper.

Friction. 10. (*a*) The adhesion of the friction coat of compound between the plies shall be such that when a strip of tape 2 ft. long and $\frac{3}{4}$ in. wide is taken from a roll and wound upon a 1-in. mandrel under tension of $7\frac{1}{2}$ lb. at the rate of 30 in. per minute, a weight of 3 lb. shall not cause the plies to separate at a greater rate than 30 in. per minute.

(*b*) After a strip has been exposed to dry heat at 100° C. for 18 hours and then cooled to room temperature, a test specimen shall withstand the test prescribed in the Paragraph (*a*), except that the weight applied to unwind the tape shall be 1 lb. instead of 3 lb.

Dielectric Strength. 11. The test for dielectric strength shall be made as follows: The tape shall be spirally wound with one-third lap on a smooth metal rod, 1 in. in diameter, for a distance of 6 in. Two inches in the center shall be covered with tin foil and bound down securely with tape, and an alternating potential of 1000 volts, of a frequency of not over 65 cycles, shall be applied for five minutes between the metal rod and the tin foil without puncture.

Test Samples. 12. One $\frac{1}{2}$-lb. roll for each 250 rolls shall be selected at random for the various tests. At least two feet of the outer layers shall be removed and one specimen taken for each test. If the tape fails in any one test, two additional specimens shall be taken. If the tape fails in either of these two additional tests, the material shall be rejected.

III. STANDARD WEIGHT, DIMENSIONS AND VARIATIONS.

Weight. 13. The net weight of the tape, $\frac{3}{4}$ in. wide, shall be not less than 8 oz. per roll, exclusive of core, wrapping, and box.

Yardage. 14. The length of $\frac{3}{4}$ in. tape shall be not less than 55 yd. per lb.

Variation in Width. 15. The width shall not vary from that specified more than ±0.03 in.

IV. PACKING AND MARKING.

Packing. 16. Each roll shall be wrapped in oiled paper or metal foil and enclosed in a suitable box. The wrapping shall be secure and shall thoroughly protect the contents.

Marking. 17. Each box shall be marked with the name of the manufacturer or trade mark, and the nominal width and weight of the tape.

V. INSPECTION.

Time of Inspection. 18. The tape shall be tested and inspected within four weeks of date of delivery.

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INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE TEST
FOR
SPECIFIC GRAVITY OF ROAD OILS, ROAD TARS, ASPHALT CEMENTS AND SOFT TAR PITCHES.[1]

Serial Designation: D 70 – 20 T.

This test is issued under the fixed designation D 70; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1920.

Definition. 1. The specific gravity of road oils, road tars, asphalt cements and soft tar pitches shall be expressed as the ratio of the weight of a given volume of the material at 25° C. (77° F.) to that of an equal volume of water at the same temperature and shall be expressed thus:

Specific gravity 25°/25° C. (77°/77° F.).

Apparatus. 2. The determination of specific gravity shall be made with a pyknometer or weighing bottle (Fig. 1), which shall consist of a straight-walled glass tube approximately 70 mm. long and 22 mm. in diameter, carefully ground to receive an accurately fitting solid glass stopper with a hole of 1.5 to 1.7-mm. bore in place of the usual capillary opening. The lower part of the stopper is made concave in order to allow all air bubbles to escape through the bore. The depth of the cup-shape depression shall be about 4.8 mm. at the center. The stoppered tube should have a capacity of about 24 cc. and, when empty should weigh not over 35 g.

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[1] Criticisms of this Tentative Test are solicited and should be directed, preferably before January 1, 1921, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third Street, New York City.

Method.

3. Before making a determination, the pyknometer with stopper shall first be calibrated by weighing it clean and dry upon an analytical balance. This weight is called "*a.*" It shall then be filled with freshly boiled distilled water at a temperature of 25° C. (77° F.), the stopper firmly inserted, all surplus moisture wiped from the surface with a clean dry cloth and again weighed. This weight is called "*b.*"

4. When determining the specific gravity of road oils or road tars which flow readily, the material shall be brought to a temperature of 25° C. (77° F.) and poured into the pyknometer until it is full, with care to prevent the inclusion of air bubbles. The stopper is then firmly inserted and all excess of material forced through the opening is carefully removed with a clean dry cloth. The pyknometer and contents are then weighed and this weight is called "*c.*" The specific gravity of the material shall be calculated from the formula:

$$\text{Specific Gravity} = \frac{c-a}{b-a}.$$

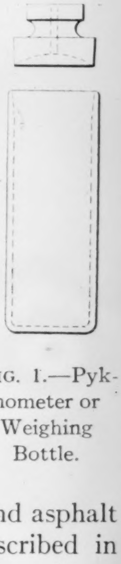

FIG. 1.—Pyknometer or Weighing Bottle.

5. When determining the specific gravity of tar and asphalt products which are too viscous for the method described in Section 4, a small amount of the material shall be brought to a fluid condition by the gentle application of heat, care being exercised to prevent loss by evaporation. When sufficiently fluid, enough is poured into the clean dry pyknometer to about half fill it. Precautions shall be taken to keep the material from touching the sides of the tube above the final level and to prevent the inclusion of air bubbles. The tube should be slightly warmed before filling. The pyknometer and contents are then cooled to room temperature and weighed with the stopper. This weight is called "*c.*" The pyknometer is next removed from the balance, filled with freshly boiled distilled water, and the stopper

firmly inserted. It is then completely immersed for not less than 30 minutes in a beaker of distilled water maintained at 25° C. (77° F.) after which it is removed, and all surplus water is wiped off with a clean cloth. It is immediately weighed. This weight is called "*d*." The specific gravity of the material shall be calculated from the formula:

$$\text{Specific Gravity} = \frac{c-a}{(b-a)\ (d-c)}$$

Precautions. 6. When making the specific gravity determination it is important that:

(*a*) Only freshly boiled distilled water shall be used.

(*b*) When weighing the pyknometer completely filled, the temperature of its contents shall be within 1° C. (1°.8 F.) of 25° C. (77° F.).

(*c*) Precautions shall be taken to prevent expansion and overflow of the contents from the heat of the hand when wiping the surface of the pyknometer.

(*d*) The presence of all air bubbles shall be eliminated in filling the pyknometer and inserting the stopper.

(*e*) Weighings shall be made quickly after filling the pyknometer and shall be accurate to 1 mg. A number of trial fillings and catch weights may be necessary to obtain the desired degree of accuracy.

(*f*) To prevent breakage of the pyknometer when cleaning it out after a determination has been made upon a very viscous or semi-solid material, it will be found advisable to warm it in an oven at not over 100° C. until most of the material may be poured out and then to swab it with a piece of soft cloth or cotton waste. When cool it may be finally rinsed with carbon disulfide, benzol or other solvent and wiped clean.

Accuracy. 7. The limit of accuracy of the test is ±0.005 specific gravity.

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TENTATIVE TEST FOR SPECIFIC GRAVITY OF ASPHALTS AND TAR PITCHES SUFFICIENTLY SOLID TO BE HANDLED IN FRAGMENTS.[1]

Serial Designation: D 71 – 20 T.

This test is issued under the fixed designation D 71; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1920.

Definition.

1. The specific gravity of asphalts and tar pitches shall be expressed as the ratio of the weight of a given volume of the material at 25° C. (77° F.) to that of an equal volume of water at the same temperature and shall be expressed thus:

Specific Gravity 25°/25° C. (77°/77° F.).

Apparatus.

2. The determination of specific gravity shall be made with an analytical balance equipped with a pan straddle or other stationary support (Fig. 1).

Test Specimen.

3. The test specimen shall be a cube of the material measuring approximately $\frac{1}{2}$ in. to the edge. It shall be prepared by melting a small sample of the material by the gentle application of heat, care being exercised to prevent loss by evaporation, and pouring when sufficiently fluid into a $\frac{1}{2}$-in. brass cubical mold,

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[1] Criticisms of this Tentative Test are solicited and should be directed, preferably before January 1, 1921, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third Street, New York City.

which has been amalgamated with mercury and which is placed on an amalgamated brass plate. Precautions should be taken to prevent the inclusion of air bubbles. The hot material should slightly more than fill the mold and when cool the excess may be cut off with a hot spatula. The specimen shall be removed from the mold when cooled to room temperature.

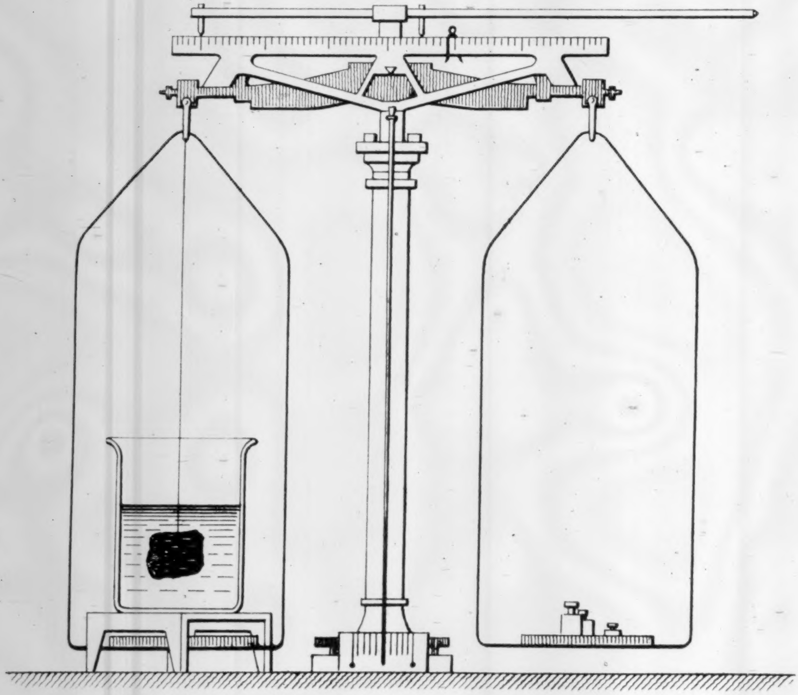

FIG. 1.—Analytical Balance Equipped with Pan Straddle.

Method. 4. The balance shall first be tared with a piece of fine waxed silk thread sufficiently long to reach from the hook on one of the pan supports to the straddle or rest. The test specimen shall then be attached to the thread, so as to be suspended about 1 in. above the straddle from the hook on the pan support, and weighed. This weight is called "*a*" and shall be accurate to 0.1 mg. The specimen, still suspended by the thread, shall then be weighed completely immersed in freshly boiled distilled water at 25° C. (77° F.) ±1° C. (1°.8 F.), adhering air bubbles being first removed with a fine wire. This weight is called "b" and shall also be accurate to 0.1 mg.

The specific gravity of the material shall be calculated from the formula:

$$\text{Specific Gravity} = \frac{a}{a-b}$$

5. The limit of accuracy of the test is ±0.005 specific gravity. **Accuracy.**

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TENTATIVE TEST
FOR
QUANTITY OF CLAY AND SILT IN GRAVEL FOR HIGHWAY CONSTRUCTION.[1]

Serial Designation: D 72 – 20 T.

This test is issued under the fixed designation D 72; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1920.

Scope. 1. This test covers the determination of the quantity of clay and silt in natural gravel to be used in highway construction.

Treatment of Sample. 2. The sample as received shall be moistened and thoroughly mixed, then dried to constant weight at a temperature between 100 and 110° C. (212 and 230° F.).

Method. 3. A representative portion of the dry material, weighing not less than 50 times the weight of the largest stone in the sample, shall be selected from the sample, and placed in a dried and accurately weighed pan or vessel. The pan shall be 12 in. (30.2 cm.) in diameter by not less than 4 in. (10.2 cm.) deep, as nearly as may be obtained. Pour sufficient water in the pan to cover the gravel and agitate vigorously for 15 seconds, using a trowel or stirring rod. Allow to settle for 15 seconds, and then pour off the water into a tared evaporating dish, taking care not to pour off any gravel. Repeat until the wash water is clear. Dry the washed material to constant weight in an oven at a temperature between 100 and 110° C. (212 and 230° F.), weigh, and determine the net weight of gravel.

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[1] Criticisms of this Tentative Test are solicited and should be directed, preferably before January 1, 1921, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third Street, New York City.

The percentage of clay and silt shall be calculated from the formula:

$$\text{Percentage of Clay and Silt} = \frac{\text{Original weight} - \text{weight after washing}}{\text{Original weight}} \times 100.$$

For a check on the results, evaporate the wash water to dryness and weigh the residue:

$$\text{Percentage of Clay and Silt} = \frac{\text{Weight of residue}}{\text{Original weight}} \times 100.$$

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TENTATIVE TEST
FOR
QUANTITY OF CLAY IN SAND-CLAY, TOPSOIL AND SEMI-GRAVEL FOR HIGHWAY CONSTRUCTION.[1]

Serial Designation: D 73 - 20 T.

This test is issued under the fixed designation D 73; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1920.

Scope. 1. This test covers the determination of the quantity of clay in that portion of sand-clay, topsoil and semi-gravel for highway construction which passes a 10-mesh sieve.[2]

Treatment of Material. 2. Dry 500 g. of the material at a temperature below 176°.6 C. (350° F.) to a constant weight. Gently pulverize to break down soft clods or masses, but not to grind or break hard material. Pass through a 10-mesh sieve, weigh the coarse residue and record as "coarse material." Use the material passing the 10-mesh sieve as the starting point of a percentage analysis as follows:

Method. 3. Weigh out two samples of 50 g. of this material for duplicate analysis. Place each in a tared wide-mouth bottle

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[1] Criticisms of this Tentative Test are solicited and should be directed, preferably before January 1, 1921, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third Street, New York City.

[2] For specifications for this sieve, see Standard Method for Making a Mechanical Analysis of Sand or Other Fine Highway Material, except for Fine Aggregates Used in Cement Concrete (Serial Designation: D 7), 1918 Book of A.S.T.M. Standards.

(5 to 6 cm. in diameter and 12 to 15 cm. high). Add about 5 cc. of dilute ammonia water and about 200 cc. of water. Close with a cork or glass stopper and shake thoroughly for 20 minutes. Allow the sample to settle 8 minutes and decant carefully or siphon off the supernatant liquid to a depth of 8 cm. below the surface of the liquid. (The depth of the liquid in the bottle should be sufficient to leave about 4 cm. below the point of siphoning.) Fill the bottle again with water, shake for 3 minutes, allow to settle, and siphon off as before. Repeat the process until the supernatant liquid is clear. Be careful to wash the stopper and neck of the bottle free from coarse material before decanting. Dry the bottle and washed material to constant weight at a temperature between 100 and 110° C. (212 and 230° F.), weigh, and determine the net weight of washed material.

The percentage of clay shall be calculated from the formula:

$$\text{Percentage of Clay} = \frac{\text{Original weight} - \text{weight after washing}}{\text{Original weight}} \times 100.$$

As a check the washings drawn off shall be collected and evaporated to dryness for direct recovery of the fine sediment classed as clay:

$$\text{Percentage of Clay} = \frac{\text{Weight of residue}}{\text{Original weight}} \times 100.$$

The determinations of percentage of clay on the two samples shall check within ±1, to be acceptable.

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TENTATIVE TEST
FOR
QUANTITY OF CLAY AND SILT IN SAND FOR HIGHWAY CONSTRUCTION.[1]

Serial Designation: D 74 – 20 T.

This test is issued under the fixed designation D 74; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1920.

Scope. 1. This test covers the determination of the quantity of clay and silt in natural sand to be used in highway construction

Treatment of Sample. 2. The sample as received shall be moistened and thoroughly mixed, then dried to constant weight at a temperature between 100 and 110° C. (212 and 230° F.).

Method. 3. A representative portion of the dry material, weighing 500 g., shall be selected from the sample, and placed in a dried and accurately weighed pan or vessel having vertical sides and provided with a pouring lip. The pan shall be substantially 9 in. (22.9 cm.) in diameter by not less than 4 in. (10.2 cm.) deep. Pour sufficient water in the pan to cover the sand (about 225 cc.) and agitate vigorously for 15 seconds. Allow to settle for 15 seconds, and then pour off the water into a tared evaporating dish, taking care not to pour off any sand. Repeat until the wash water is clear, using a glass rod to stir the material for the last few washings. Dry the pan and washed sand to constant weight in an oven at a temperature between 100 and 110° C. (212 and 230° F.), weigh, and determine the net weight of sand.

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[1] Criticisms of this Tentative Test are solicited and should be directed, preferably before January 1, 1921, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third Street, New York City.

The percentage of clay and silt shall be calculated from the formula:

$$\text{Percentage of Clay and Silt} = \frac{\text{Original weight} - \text{weight after washing}}{\text{Original weight}} \times 100.$$

For a check on the results, evaporate the wash water to dryness and weigh the residue:

$$\text{Percentage of Clay and Silt} = \frac{\text{Weight of residue}}{\text{Original weight}} \times 100.$$

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TENTATIVE TESTS
FOR
MOLDED INSULATING MATERIALS.[1]

Serial Designation: D 48 - 17 T.

These tests are issued under the fixed designation D 48; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1917.

Material Covered. 1. These tests are intended to apply to all solid insulating materials that are formed in molds or between platens by the application of pressure, either with or without heat.

I. PHYSICAL PROPERTIES AND TESTS.

(*A*) *Mechanical.*

TENSILE STRENGTH.

Specimen. 2. The standard test specimen shown in Fig. 1 shall be used for the tension test. It shall be molded in a hardened and ground steel mold to the dimensions given in Fig. 1.

Apparatus. 3. Any standard testing machine may be used. Special clips (see Fig. 1) of hardened steel shall be used, hung from links held in the jaws of the machine, so that the pull is central at all times, to avoid any transverse strain.

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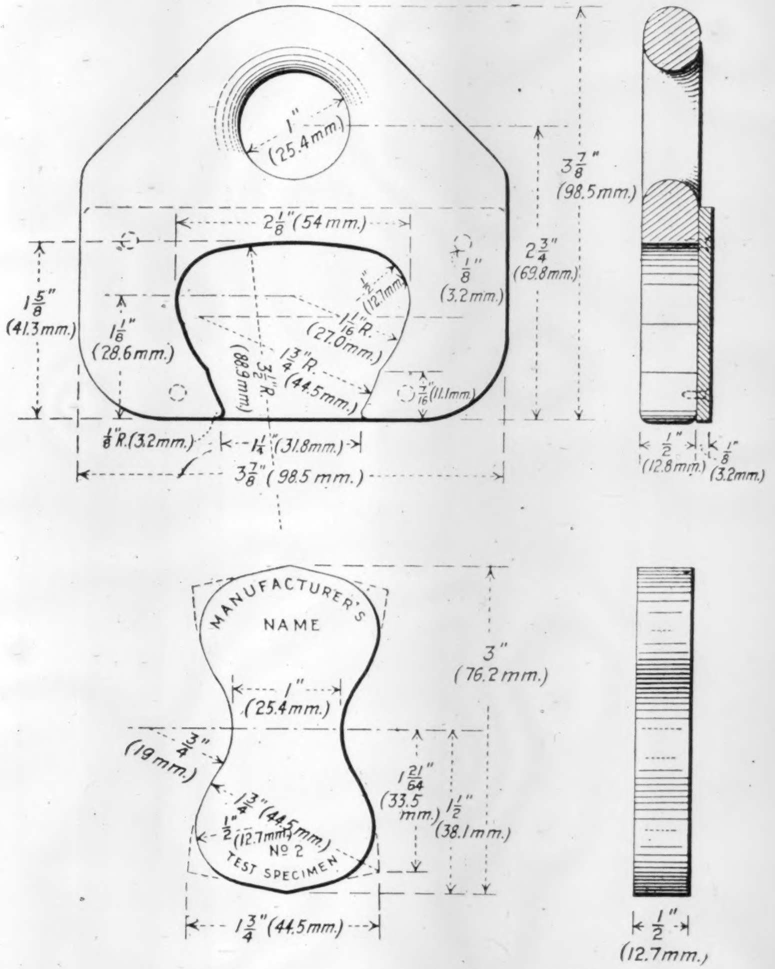
[1] Criticisms of these Tentative Tests are solicited and should be directed, preferably before January 1, 1921, to Mr. F. M. Farmer, Chairman of Committee D-9 on Electrical Insulating Materials, Electrical Testing Laboratories, Eightieth St. and East End Ave., New York City.


1" (25.4 mm.)
$3\frac{7}{8}$" (98.5 mm.)
$2\frac{3}{4}$" (69.8 mm.)
$2\frac{1}{8}$" (54 mm.)
$\frac{1}{8}$" (3.2 mm.)
$\frac{1}{2}$" (12.7 mm.)
$1\frac{1}{16}$" R. (27.0 mm.)
$1\frac{3}{4}$" R. (44.5 mm.)
$3\frac{1}{2}$" R. (88.9 mm.)
$\frac{7}{16}$" (11.1 mm.)
$1\frac{5}{8}$" (41.3 mm.)
$1\frac{1}{8}$" (28.6 mm.)
$\frac{1}{8}$" R. (3.2 mm.)
$1\frac{1}{4}$" (31.8 mm.)
$3\frac{7}{8}$" (98.5 mm.)
$\frac{1}{2}$" (12.8 mm.)
$\frac{1}{8}$" (3.2 mm.)
MANUFACTURER'S
NAME
3" (76.2 mm.)
1" (25.4 mm.)
$\frac{3}{4}$" (19 mm.)
$1\frac{3}{4}$" (44.5 mm.)
$\frac{1}{2}$" (12.7 mm.)
Nº 2
TEST SPECIMEN
$1\frac{21}{64}$" (33.5 mm.)
$1\frac{1}{2}$" (38.1 mm.)
$1\frac{3}{4}$" (44.5 mm.)
$\frac{1}{2}$" (12.7 mm.)

Make Steel Mold to these Dimensions. Limits ± 0."002 (0.05 mm.)

FIG. 1.—Tension Test Specimen (Specimen No. 2.)

Method. 4. (*a*) Six specimens shall be tested in the condition in which they are received.

Three specimens shall be tested after heating in an oven for one hour at a temperature which is 10° C. (18° F.) below the distortion point of the material, as determined under Part (*C*), Sections 18 to 21. The test shall be made while the specimens are hot, with a permissible variation of ±5 per cent from the temperature taken.

Three specimens shall be tested after they have been entirely immersed in distilled water for 48 hours at normal room temperature. The specimens shall be pulled apart at normal room temperature of about 21° C. (70° F.) after the surface water has been removed by wiping with a dry cloth.

(*b*) The test specimen shall be pulled apart at such a speed that the beam can be kept well balanced. Make all tests at normal room temperature of about 21° C. (70° F.). Measurements may be taken at intervals during the test to show the elongation of the specimen when required for elastic materials.

Report. 5. The results of the test shall be reported in the following order:

(*a*) The breaking load of each specimen in kilograms or pounds;

(*b*) The thickness in centimeters or inches as measured by micrometer at the point of fracture;

(*c*) The average ultimate tensile strength in kilograms per square centimeter or in pounds per square inch, as calculated from the actual area of the specimen measured at the point of fracture;

(*d*) State the character of the material tested and describe how it acts under strain;

(*e*) The speed in centimeters or inches per minute at which the jaws traveled during the test.

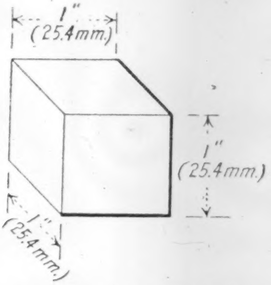
COMPRESSIVE STRENGTH.

Specimen 6. The test specimen shall be molded in the form of a cube from a hardened steel mold, ground to the dimensions shown in Fig. 2.

Apparatus. 7. Any standard testing machine may be used. The pressure head used for standard compressive strength test on cement blocks is satisfactory for this purpose. Place a sheet of lead $\frac{1}{16}$ in. thick both above and below the specimen to adjust irregularities.

Method. 8. (*a*) Six specimens shall be crushed in the condition in which they are received.

Three specimens shall be crushed after heating for one hour at a temperature which is 10° C. below the distortion point of the material, as determined under Part (*C*), Sections 18 to 21. The test shall be made while the specimens are hot, with a permissible variation of ±5 per cent from the temperature taken.



Manufacturer's Name and "Test Specimen No. 3" Molded on Top in Small Round Body Raised Letters.
Make Steel Mold to these Dimensions.
Limits ± 0."002 (0.05mm.)

FIG. 2.—Compression Test Specimen (Specimen No. 3).

Three specimens shall be crushed after immersion in distilled water at normal room temperature for 48 hours, with all surface water wiped off with a dry cloth.

(*b*) The load shall be applied at such a rate of speed that will permit the beam to be kept well balanced, from zero load until the specimen is crushed. For best results use the slowest possible speed.

Report. 9. The results of the test shall be reported in the following order:

(*a*) The dimensions of each specimen in millimeters or in inches;

(*b*) The breaking load in kilograms or in pounds, on each specimen at the first sign of failure.

(*c*) The average ultimate compressive strength in kilograms per square centimeter or in pounds per square inch, of each set of specimens, calculated from the measured area of each specimen before the load is applied.

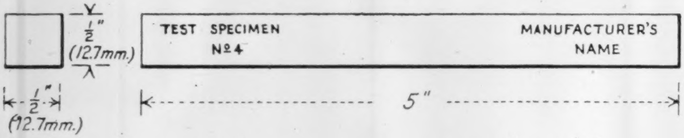
(*d*) State the general character of the material tested and describe how it acts under the applied load;

(*e*) The speed in centimeters or inches per minute at which the jaws traveled during the test.

TRANSVERSE STRENGTH.

Specimen. 10. The test specimen shall be molded from a hardened steel mold, ground to the dimensions shown in Fig. 3.

Apparatus. 11. Any standard testing machine may be used. The specimen shall be supported on two steel blocks, with corners rounded to $1\frac{1}{2}$-mm. ($\frac{1}{16}$-in.) radius. These supports shall be 100 mm. (3.94 in.) apart. The load shall be applied on top of this specimen by means of a wedge-shaped pressure piece, the edge of which is rounded to a 3-mm. ($\frac{1}{8}$-in.) radius, extending across the specimen with the edge parallel to the edges of the two supports. The angle of the wedge shall be approximately 45 deg., and the load shall be applied at right angles to the specimen midway between the supports. The specimen shall be laid flat upon the supports at equal distances from the edges at each end.



Make Steel Mold to these Dimensions. Limits ± 0.″002 (0.05mm.)

FIG. 3.—Transverse Test Specimen (Specimen No. 4)

Method. 12. (*a*) Six specimens shall be tested in the condition in which they are received.

Three specimens shall be tested after immersion in distilled water at normal room temperature for 48 hours, with all surface water wiped off with a dry cloth.

(*b*) The load shall be applied at as slow a speed as possible, so that the beam may be kept well balanced from zero load until the first sign of failure. All tests shall be made at room temperature of about 21° C. (70° F.). Measurements of the deflection may be taken for very elastic materials.

Report. 13. The results of the test shall be reported in the following order:

(*a*) The thickness of each specimen as measured by micrometer in millimeters or in inches;

(*b*) The actual breaking load of each specimen in kilograms or in pounds at the first sign of failure.

(*c*) The maximum fiber stress in kilograms per square centimeter or in pounds per square inch calculated by the formula,

$$S = \frac{3\,PL}{2\,BD^2},$$

in which S = maximum fiber stress, P = load applied, L = distance between the supports, B = width of specimen, and D = depth of specimen;

(*d*) The rate at which the load was applied;

(*e*) The amount of deflection in millimeters or inches.

(*B*) *Electrical.*

DIELECTRIC STRENGTH.

Specimen. 14. The test specimen shall be molded to the dimensions shown in Fig. 4. The mold shall be hardened and ground to these dimensions. If the material cannot be molded to the full height shown, the height can be reduced to $1\frac{1}{4}$ in., other dimensions remaining the same.

Apparatus. 15. (*a*) Any well-designed high tension testing transformer, connected to an alternating current supply having as nearly a true sine wave as possible, may be used. The transformer and the source of supply of energy shall not be less than 5 KVA. The frequency shall not exceed 100 cycles per second.

(*b*) Regulation shall be so controlled that the high tension testing voltage taken from the secondary of the testing transformer can be raised gradually from any point. The control may be made by generator field regulation, by the potentiometer method, with an induction regulator, or with a variable ratio auto transformer. Any method of regulating the voltage is satisfactory which does not distort the wave more than ten per cent from a sinusoidal shape.

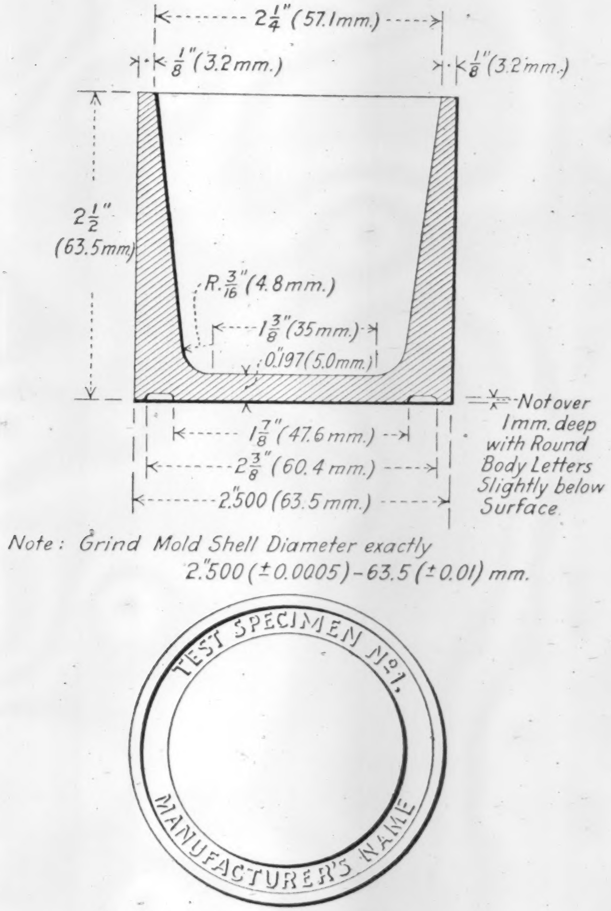
(*c*) The voltage may be measured by any approved method, preferably by connecting a voltmeter to an auxiliary ratio transformer coil, reading square root of mean square volts in the primary of the testing transformer. A voltmeter on the low tension side of the transformer is satisfactory, if the ratio of transformation does not change under any test condition. An electrostatic voltmeter properly calibrated in the high tension circuit is also satisfactory. A spark gap may be used to check the readings at very high potentials.

Some protection is desirable in the high tension circuit of testing transformers where the voltage is from 25,000 to 100,000 volts, to prevent dangerous surges and limit the current when the test specimen is punctured. It is, however, desirable to have as much energy available as possible when puncture occurs. If impedance in the form of choke coils be used in series with the high tension terminals, it should not be greater than that which will limit the high tension current to double the normal rated current of the testing transformer.

When a spark gap is used a non-inductive resistance of about 1 ohm per volt may be inserted in series with one terminal of the spark gap, to damp high frequency oscillations at the time of breakdown and limit the current flow. This resistance shall be as near the gap as possible and in series with the test specimen. If the test is made with one side grounded this resistance shall be on the ungrounded side of the circuit, and if neither side is grounded the resistance shall be inserted one-half on each side of the spark gap. Water tube resisters are preferable to carbon for this purpose, as carbon resistance may become very low at high voltage.

(*d*) The apparatus used shall meet the requirements of the Standardization Rules of the American Institute of Electrical Engineers.

Method. 16. (*a*) Voltage shall be applied to the test specimen by placing a wet clay pat about $\frac{1}{4}$ in. thick inside the specimen and extending all around to the wall and another wet clay pat


2¼" (57.1mm.)
⅛" (3.2mm.)
⅛" (3.2mm.)
2½" (63.5mm)
R. 3/16" (4.8mm.)
1⅜" (35mm.)
0.197 (5.0mm.)
1⅞" (47.6 mm.)
2⅜" (60.4 mm.)
2.500 (63.5 mm.)
Not over 1mm. deep with Round Body Letters Slightly below Surface.
TEST SPECIMEN No. 1.
MANUFACTURER'S NAME

Note: Grind Mold Shell Diameter exactly 2.500 (± 0.0005) - 63.5 (± 0.01) mm.

Make Steel Mold to these Dimensions.
Limits ± 0.002 (0.05 mm.)

FIG. 4.—Test Specimen for Dielectric Strength (Specimen No. 1).

on the bottom extending to within about $\frac{1}{8}$ in. of the edge. Whenever it is impossible to puncture the specimen in air without arcing over the edge, it shall be deeply immersed in high grade transformer oil. On specimens which require a very high voltage to puncture it may be necessary to put a glass tube or shield over the wire leading to the inside in order to prevent breakdown over the surface of the oil between terminals. The testing voltage shall be raised from zero at a constant rate of approximately 1000 volts per second until puncture occurs.

(*b*) Ten specimens shall be punctured in the condition received at normal room temperature of about 21° C. (70° F.) in order to determine the uniformity of the molded material.

Five specimens shall be punctured after heating for one hour in an oven heated to 10° C. (18° F.) below the distortion point of the material as determined under Part (*C*), Sections 18 to 21. Puncture tests shall be made at this temperature with a permissible variation of ±5 per cent in degrees Centigrade. This test is intended to cover all molded materials which do not stand working temperatures above 125° C. (257° F.). Tests on materials which resist very high temperatures may be made above 125° C. (257° F.) when required.

Five specimens shall be punctured after they have had the rim immersed in melted paraffin for a depth of 1 in. and been entirely immersed in distilled water for 48 hours at normal room temperature of about 21° C. (70° F.). The surface of the specimen shall be wiped off with a dry cloth to remove all trace of excessive surface moisture and the puncture test shall be made in oil when necessary and at normal room temperature.

Report. 17. The results of tests shall be reported in the following order:

(*a*) The thickness of each specimen measured by micrometer in the direction perpendicular to its bottom surface, regardless of the path taken by the discharge. The thickness of all specimens shall be given in millimeters or mils.

(*b*) The puncture voltage of each test specimen and the average volts per millimeter or per mil as calculated from the average thickness of the specimens. Also give the maximum and minimum volts per millimeter or per mil.

(*c*) State the general character of the material tested with regard to leakage, if any is observed, and give the puncture voltage in volts per unit of thickness withstood by the bottom section whenever puncture takes place on the side of the specimen. This indicates the dielectric strength under both favorable and unfavorable conditions of molding. Experience shows that very plastic materials which flow easily when hot always puncture through the bottom, while materials which do not flow readily will often puncture through the side walls of a specimen at some distance up from the bottom.

(*d*) Report the frequency of the electrical circuit from which the test voltage is obtained.

(*C*) *Thermal.*

DISTORTION UNDER HEAT.

Specimen. 18. The same test specimen shall be used for this test as required for the transverse strength test, Section 10, molded from a hard steel mold ground to the dimensions given in Fig. 3.

Apparatus. 19. A special apparatus shall be used for this test as shown in Fig. 5. The specimen is supported on steel supports 100 mm. (3.94 in.) apart with the load applied on top of the specimen vertically and midway between the supports, the same as for the transverse test. The machine shall be arranged to apply two different loads, 2.5 kg. (5.512 lb.) and 5 kg. (11.023 lb.). The specimen shall be placed in an air bath surrounded by an oil bath which is so arranged that its temperature may be raised gradually. The machine shall be so arranged that the deflection of the specimen at its center between the supports can be measured on a scale in millimeters or mils and shall be equipped with a thermometer so that the temperature of the specimen can be recorded at any time. The machine may be arranged to automatically shut off the heat and sound an alarm as soon as the required deflection is reached.

Method. 20. Three test specimens shall be tested in the condition in which they are received, starting at normal room temperature of 21° C. (70° F.) and increasing the temperature of the specimen gradually at the rate of approximately 1° C. every two minutes.

The distortion point shall be considered the temperature at which the specimen has deflected 0.254 mm. (10 mils) at the center between the supports.

Report. 21. The results of the test shall be reported in the following order:

(*a*) The distortion point in degrees Centigrade and also in degrees Fahrenheit;

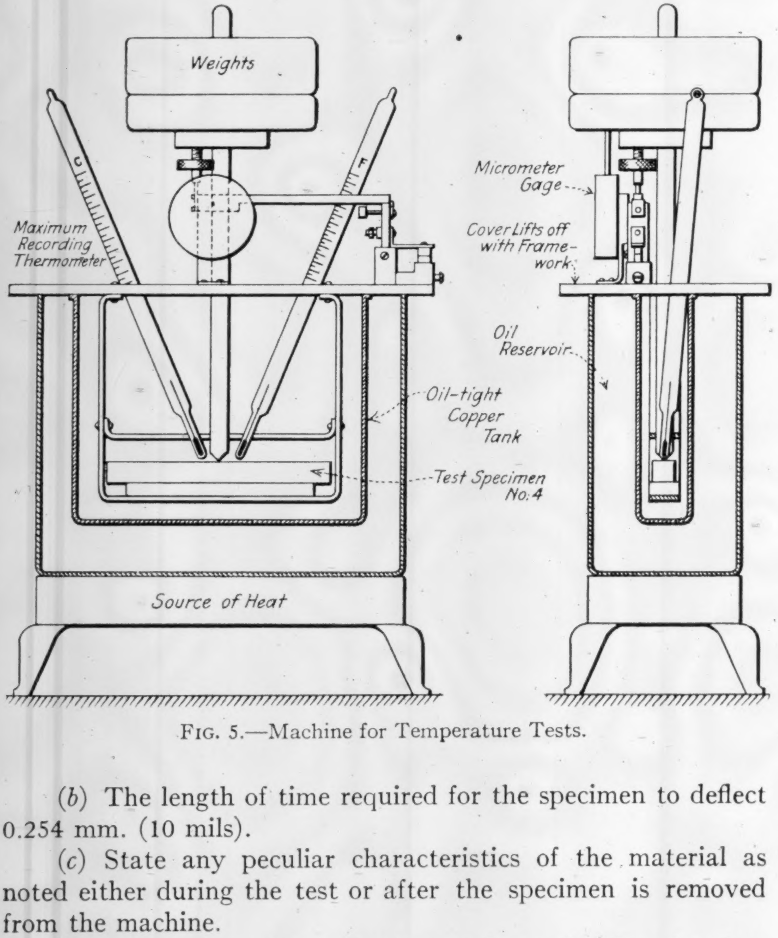

Weights
C
F
Maximum Recording Thermometer
Micrometer Gage
Cover Lifts off with Frame-work
Oil Reservoir
Oil-tight Copper Tank
Test Specimen No. 4
Source of Heat

FIG. 5.—Machine for Temperature Tests.

(*b*) The length of time required for the specimen to deflect 0.254 mm. (10 mils).

(*c*) State any peculiar characteristics of the material as noted either during the test or after the specimen is removed from the machine.

(*d*) Plot a curve for each test specimen showing the time

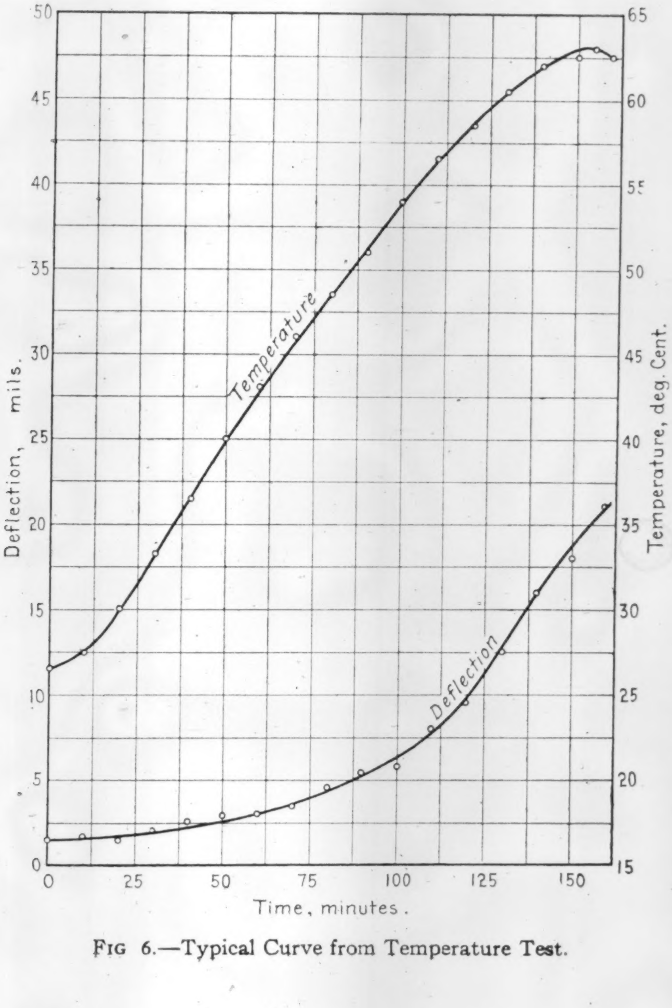


FIG 6.—Typical Curve from Temperature Test.

in minutes horizontally and the amount of deflection and also the temperature at given intervals, using vertical ordinates as shown in Fig. 6.

(*D*) *Effect of Moisture.*

Specimen. 22. One-half of the standard test specimen shown in Fig. 1 shall be used for this test. This specimen shall be broken in half and all loose particles removed.

Apparatus. 23. Any good chemical balance may be used; also, a beaker of distilled water at normal room temperature of about 21° C. (70° F.), and an oven of any standard make, capable of maintaining a uniform temperature of 100° C. (212° F.), ± 5° C.

Method. 24. Weigh carefully three test specimens in the condition in which they are received. If the material softens readily at moderate temperatures, the specimens may be placed in a desiccator for 24 hours, or in an oven at a temperature of 50° C. (122° F.), ± 5° C., for 24 hours. For materials which do not soften readily the specimens shall be placed in an oven heated to 100° C. (212° F.), ± 5° C., for 24 hours. After drying, the specimens shall be weighed again at normal room temperature. Place the specimens in distilled water, wholly immersed, for 100 hours at normal room temperature. Remove the specimens at the end of 100 hours, wipe off all surface water with a dry cloth and weigh carefully.

Report. 25. The results of the test shall be reported in the following order:

(*a*) The original weight of each specimen;

(*b*) The dry weight of each specimen;

(*c*) The saturated weight in grams of each specimen after immersion for 100 hours;

(*d*) The percentage of moisture contained in each test specimen as received, and the percentage of moisture absorbed during 100 hours, taking the dry weight as 100 per cent. Give the average for the three specimens.

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PHILADELPHIA, PA., U. S. A.
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INTERNATIONAL ASSOCIATION FOR TESTING MATERIALS.

TENTATIVE METHODS
FOR
SAMPLING OF STONE, SLAG, GRAVEL, SAND AND STONE BLOCK FOR USE AS HIGHWAY MATERIALS.[1]
INCLUDING SOME MATERIAL SURVEY METHODS.

Serial Designation: D 75 – 20 T.

These methods are issued under the fixed designation D 75; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1920.

1. Samples of all materials for test upon which is to be based the acceptance or rejection of the supply shall be taken by the engineer or his authorized representative. Samples for inspection or preliminary test may be submitted by a producer or owner of the supply.

I. SAMPLING OF STONE.

A. Sampling of Stone from Ledges or Quarries for Quality.

Inspection.

2. The ledge or quarry face shall be inspected closely to determine any variation in different layers. Any difference in color or structure shall be observed, and if necessary to secure unweathered specimens, pieces broken from different layers.

Sampling and Size.

3. (*a*) For standard stone test, separate samples shall be taken of at least 30 lb. each of fresh unweathered specimens

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[1] Criticisms of these Tentative Methods are solicited and should be directed, preferably before January 1, 1921, to Mr. Prévost Hubbard, Secretary of Committee D-4 on Road and Paving Materials, 25 W. Forty-third Street, New York City.

from all layers that appear to vary in color or structure. When more than one piece is taken, the minimum size shall be 2 in., except that there shall be one piece of each sample of a minimum size of 4 by 5 by 3 in. on which the bedding plane is marked and which shall be free from seams or fractures to be used in the toughness or compression test.

(*b*) The sample for concrete test will depend on the kind of tests to be made and the number of specimens necessary.

Record. 4. In addition to the general information accompanying all samples, samples from local ledges not commercial sources shall contain the following: Name of owner; approximate quantity available (if quantity is very large this can be recorded as practically unlimited); amount and character of overburden or stripping; haul to nearest point on road where the material is to be used; character of haul (kind of road and grade); also some detailed record of the extent and location of the material represented by each sample. For this purpose a sketch, plan and elevation showing the thickness and location of the different layers is recommended.

B. Sampling of Stone from Commercial Quarries.

For Quality. 5. Where practical, samples from commercial quarries shall be taken from the ledge or quarry face and the same procedure shall be followed as when sampling local ledges.

For Size. 6. At the plant, the following factors affect the size of broken stone: Size and shape of screen openings; length of screen sections; the angle of screen with horizontal; the speed of screen rotation; and the rate at which the screen is fed. A general inspection and record of these conditions shall be made. The sample shall be taken preferably from cars or boats while loading from stock piles or bins. It is recommended, in order that the sample may be representative, that separate samples be taken at different times while the material is being loaded. If the sample has to be taken from the bin or stock pile, several samples shall be taken from different parts of the stock pile and from the top of the bin and the loading chute. These separate samples shall be well mixed in a composite sample and the sample for test obtained by the quartering method.

Sampling at Delivery.

7. (*a*) Where it is not practical to visit the plant, samples for both quality and size shall be taken from different parts of the car or boat during unloading. It is recommended that separate samples be taken from the top, middle and bottom of car or boat. These separate samples shall be well mixed in a composite sample and the sample for test obtained by the quartering method. The results of tests on crushed stone for quality are not considered comparable with results from samples specially broken for test in the laboratory, but the general quality of the stone can be ascertained and check tests on various shipments should indicate any change in quality. In this case, tests for both quality and size can be made on the same sample.

(*b*) Where test is to be made for size only, it is recommended that a small set of screens and a pair of scales or some unit measure receptacle for measuring volume be used for field testing in order not to delay decision on the use of the material. Occasional check tests can be obtained from the laboratory to assure a fair degree of accuracy in field testing.

Size of Samples.

8. (*a*) The sample of crushed stone for mechanical analysis shall weigh at least 50 times the weight of the largest piece therein.

(*b*) The sample for concrete test will depend on the kind of tests to be made and the number of specimens necessary.

C. Sampling of Field Stone and Boulders.

For Quality.

9. A detailed inspection of the deposits of field stone and boulders, over the area where the supply is to be obtained, shall be made. The different kinds of stone and its state of preservation in the various deposits shall be recorded.

Separate Samples.

10. Separate samples shall be taken of all stone of different classes that a visual inspection indicates, from state of preservation and degrees of lamination, would be considered for use in construction.

Record.

11. Records accompanying samples of field stone and boulders, in addition to general information, shall contain the following:

(*a*) Location of supply;

The plotting of the field stone and boulder area on a U. S. topographic or a similar map is recommended for this purpose.

(*b*) Approximate quantity available;

A fairly accurate estimate of amount of stone in fences can be made by measuring a cross-section and pacing the length. It is more difficult to estimate the amount of stone scattered on the ground and ordinarily such deposits do not pay to work unless quite congested.

(*c*) Information regarding the percentage of different classes of stone which were sampled and the percentages of material which can be rejected by visual examination and may have to be handled and spoiled.

This information regarding the percentages of different kinds of material can only be estimated and the degree of accuracy attained will depend almost entirely upon the experience and skill of the individual.

II. SAMPLING OF BLAST-FURNACE SLAG.

For Size and Quality.

12. It is recommended that blast-furnace slag be sampled for size and quality by the method specified for broken stone.

III. SAMPLING OF SAND AND GRAVEL.

A. Non-Commercial Deposits.

Definition.

13. Non-commercial as used here includes all undeveloped sand and gravel deposits and all developed deposits where the material is not washed or screened.

Sampling.

14. (*a*) The investigator should realize that few if any natural sand and gravel deposits are uniform, and when a sample is taken the quantity of material in the deposit similar to the sample shall be ascertained as nearly as possible.

(*b*) Where possible, samples of sand shall be taken when it is in a damp condition

(*c*) If the deposit is worked as a bank or pit and has an open face, the sample shall be taken by channeling the open face so as to represent material that visual inspection indicates could be used. Care shall be taken to eliminate any overburden or stripping at the top or any that has fallen along the face from the top. It is necessary, especially in small deposits, to excavate test pits some distance back of and parallel to the face to determine the extent of the supply. The number and depth of these pits depend on the quantity of material that is to be taken from the deposit. Separate samples shall be taken from the face of the bank and from test pits. These shall be well mixed in a composite sample and the sample for test obtained by the quartering method.

(*d*) Deposits that have no open face shall be sampled by means of test pits. The number and depth of these will depend on local conditions and the amount of material to be used from the source. A separate sample shall be taken from each pit and where visual examination indicates no radical difference in size of grain, color, etc., these shall be well mixed in a composite sample and the sample for test obtained by the quartering method. Where visual inspection indicates a distinct difference in material from different pits, separate samples shall be taken for test.

(*e*) It is suggested that the colorimetric test be used for determining the percentage of organic material.[1]

Record.

15. In addition to the general information accompanying all samples from sand and gravel deposits not commercial sources, the same detailed information shall be supplied as with samples of stone taken from local ledges.

B. Commercial Sand and Gravel Plants.

Sampling for Quality.

16. Samples of both sand and gravel from commercial screening or washing plants shall be taken from the bins or storage piles preferably while the material is being loaded from these supplies. The sand and gravel shall be sampled as separate units and shipped as such. It is difficult to secure a representative sample from stock piles and bins and, if conditions require sampling from these sources, the following is recommended: Separate samples shall be taken from different parts of the stock pile, care being taken to avoid sampling a segregated area of coarse-grained material which is likely to exist at the base of the pile. In sampling from a bin, separate samples shall be taken from the top and the loading chute. At the latter place at least ½ cu. yd. of material shall be run off and representative samples taken from it. These separate samples shall be well mixed in a composite sample and the sample for test obtained by the quartering method.

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[1] For a description of this test, see *Proceedings*, Am. Soc. Test. Mats., Vol. XIX, Part I, p. 321 (1919); also, Vol. XVII, Part I, p. 327 (1917).

Sampling for Size.

17. The size of sand and gravel will be affected by the same factors as broken stone and the same inspection is necessary. In addition, the relative amount of water used in screening must be taken into consideration. The same procedure for taking a sample of broken stone for size is recommended for sampling sand and gravel for size, both at plant and at delivery.

Sampling at Delivery.

18. Where it is not practical to visit the plant, samples for both quality and size shall be taken from different parts of the car or boat during unloading. It is recommended that separate samples be taken from the top, middle and bottom of car or boat. These separate samples shall be well mixed in a composite sample and the sample for test obtained by the quartering method.

C. Quantity of Sand and Gravel Samples.

Run of Bank.

19. Samples of run of bank (where the sand and gravel are combined) shall consist of at least 100 lb. of material where the gravel content is 50 per cent or more of the whole. If the gravel is less in percentage, the sample shall be increased in proportion. For example, where the gravel percentage is 25 per cent of the whole the sample should contain 200 lb.

Sand.

20. Samples of sand shall contain at least 20 lb. of material.

Gravel.

21. Samples of gravel shall contain at least 50 lb. of material.

Sample for Concrete Test.

22. The sample for concrete test will depend on the kind of tests to be made and the number of specimens necessary.

IV. SAMPLING OF MISCELLANEOUS MATERIALS.

23. Samples of slag, sand, screenings, mine tailings, and all other materials used as a substitute for sand and gravel or broken stone, shall be inspected in the same manner and samples taken in the same way as the materials for which they are substituted.

V. SAMPLING OF STONE BLOCK.

Where Sampled

24. Samples shall be taken either at the quarry or from cars or boats as directed by the engineer. They shall be representative of the block which it is proposed to use and no sample shall include blocks that would be rejected by visual inspection.

Size of Sample.

25. The sample shall consist of at least six blocks and the bedding plane shall be marked on at least two of these.

VI. GENERAL DIRECTIONS FOR SHIPPING AND MARKING SAMPLES.

Stone and Slag.

26. Samples of ledge stone, crushed stone and slag shall be shipped in a secure box or bag.

Stone Block.

27. Samples of stone block shall be securely crated.

Gravel, Sand, Etc.

28. Samples of run of bank gravel, sand screenings, and other fine material, shall be shipped in a tight box or closely woven bag so there shall be no loss of the finer particles.

Marking.

29. Each sample or separate container shall be accompanied by a card or regular form, preferably in the container, giving the following information: By whom taken, official title or rank of the sampler; by whom submitted; source of supply; proposed use for the material; and in case of commercial supplies, daily production; geographic location, shipping facilities (name of railroad, canal or river, or other common carrier); and price of the material.

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TENTATIVE METHOD
FOR
DETERMINATION OF FUSIBILITY OF COAL ASH.[1]

Serial Designation: D 22 – 19 T.

This method is issued under the fixed designation D 22; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1919.

APPARATUS.

Standard Furnace.—The No. 3 melter's furnace of the American Gas Furnace Co., shall be used, or its equivalent.

The No. 3 melter's furnace is a type of pot furnace especially suitable for fusion determination in that the burners, three in number, are on a tangent near the base of the furnace, thus producing a rotary flame which completely surrounds the crucible in which the cones are placed. The whirling flame heats the crucible uniformly and when the furnace is operated with excess gas supply, a reducing atmosphere is maintained within the crucible, which condition gives the lowest point at which the ash fuses. The air should be supplied at an approximate pressure of 3 lb. per sq. in., and either natural or artificial gas may be used.

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[1] Criticisms of this Tentative Method are solicited and should be directed, preferably before January 1, 1921, to Mr. A. C. Fieldner, Chairman of Committee D-3 on Methods of Sampling and Analysis of Coal, Fortieth and Butler Sts., Pittsburgh, Pa.

This method, when adopted as standard, will be added to the present Standard Methods for Laboratory Sampling and Analysis of Coal (Serial Designation: D 22–16), 1918 Book of A. S. T. M. Standards.

The furnace proper consists of three easily replaceable fire-clay parts, namely, a lower cylinder containing the three tangential tuyeres, and forming the bottom of the furnace, a removable upper cylinder 7 in. in internal diameter and 7 in. high, and a cover plate $1\frac{1}{2}$ in. thick, having a vent hole in the center for the flue gas.

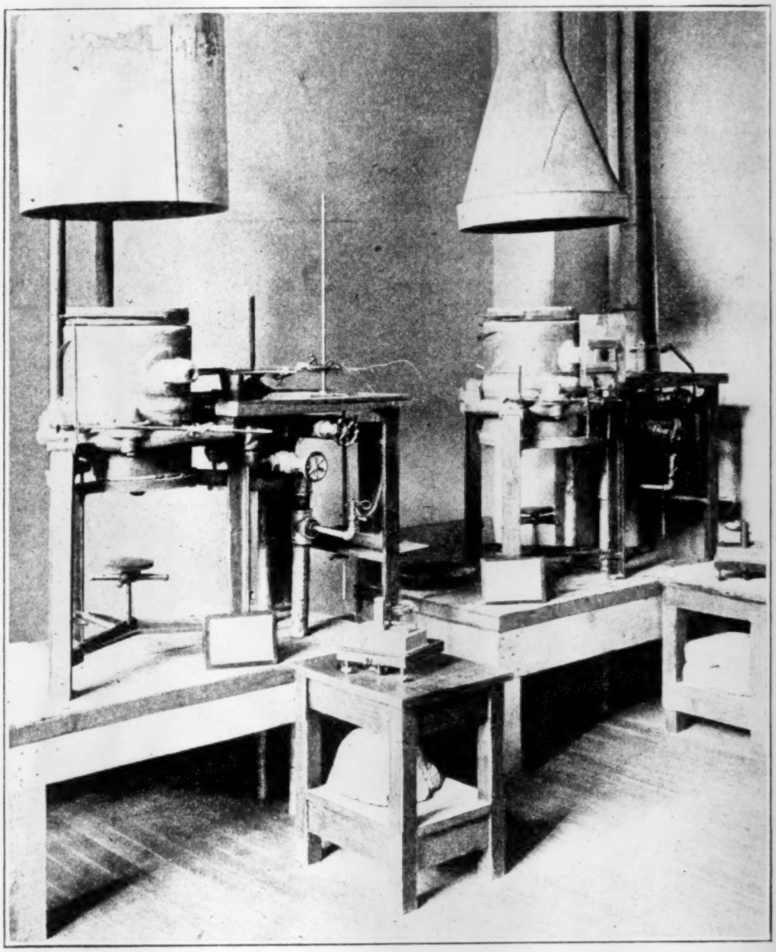

FIG. 1.—No. 3 Melter's Furnace and Accessories.

The stock design should be modified by furnishing the upper cylinder with two holes in the side: a 2-in. observation hole with its center 4 in. from the top of the cylinder (excluding cover plate), and a 1-in. thermocouple hole 90 deg. to the right of the observation hole; the bottom of these two holes being in the same horizontal plane. The interior of the furnace is cylindrical and approximately 7 in. in diameter and 11 in. high.

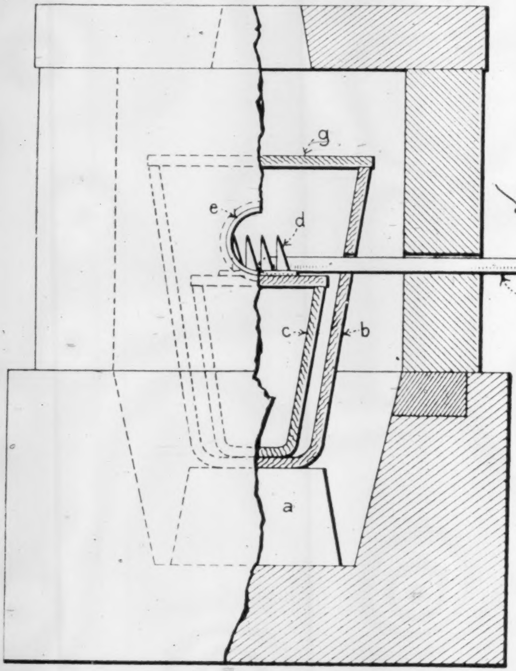

FIG. 2.—Section of No. 3 Melter's Furnace Arranged for Fusion Tests.

A counter-balanced sheet-iron canopy is connected with a telescopic 8-in. flue to an exhaust system to conduct the hot gases out of the room. Two melter's No. 3 furnaces and accessories are shown in Fig. 1.

The joint between the upper and lower cylinder is made fairly gas-tight by spreading on the top of the lower cylinder a thick paste of alundum cement to a depth of $\frac{1}{2}$ in. and then firmly pressing the upper cylinder into place. The outer part of the joint is also smoothed over with alundum cement. The fire-clay furnace cylinders and cover will withstand a temperature of about 1650° C.

Refractory Crucibles.—The interior of the furnace as arranged for making a test is shown in Fig. 2. The ash cones *d* are supported on a plate of alundum cement serving as a cover for crucible *c* which is a Denver fire-clay hard burned crucible, No. E, 4½ in. high and 3 in. in diameter at the top. The cone-supporting crucible is within the crucible *b* which with the cover *g* serves as a muffle. Crucible *b* is a Denver fire-clay hard burned crucible, No. K, 7¼ in. high and 4⅝ in. in diameter at the top, and rests on fire-clay support *a*. This crucible should be provided with two holes in the side, an observation hole 1¾ in. in diameter with its center 2 in. from the top of the crucible and a thermocouple hole 1 in. in diameter, 90 deg. to the right of the observation hole. The bottom of this hole should be in the same horizontal plane as the bottom of the observation hole. The hard burned fire-clay crucibles will not withstand a temperature exceeding 1500° C. The average life of a fire-clay crucible under these conditions is about six runs.

Corundite crucibles and covers of the Massillon Stone and Fire Brick Co. are longer lived than the fire-clay crucibles, being good for about fifty runs. A special form used by the Bureau of Mines is 3 in. inside diameter, 4½ in. high outside, with a wall thickness of about ½ in. Crucibles should be provided with two holes in the side, an observation hole 2 in. in diameter with its center 1¾ in. above the bottom of the crucible, and a thermocouple hole 1 in. in diameter, 90 deg. to the right of the observation hole. The bottom of this hole should be in the same horizontal plane as the bottom of the observation hole.

Observation Tube.—A fused silica or refractory porcelain tube *f*, 1⅞ in. in external diameter and 6 in. long, is placed in the 2 in. observation hole of the furnace, the inner end being flush with the inside furnace wall and the other end projecting out of the furnace. A brass sleeve carrying a thin glass window is slipped on the outer end of the observation tube to prevent the escape of burning gas, which would interfere with a convenient observation of the cones.

Blowing Tube.—At furnace temperatures above 1000° C., it is very difficult to observe the ash cones. A Marquadt, Usalite, Impervite or equal quality porcelain blowing tube $\frac{1}{4}$ in. in diameter is inserted through the same hole as the thermocouple tube. This tube has small perforations along one side by which air may be forced upon the cones at the time of making the observation, thus momentarily cooling the ash cones and rendering them visible. The blowing tube is connected to the compressed air line by means of rubber tubing and the air is let into the tube at the time of observation by means of a pinchcock.

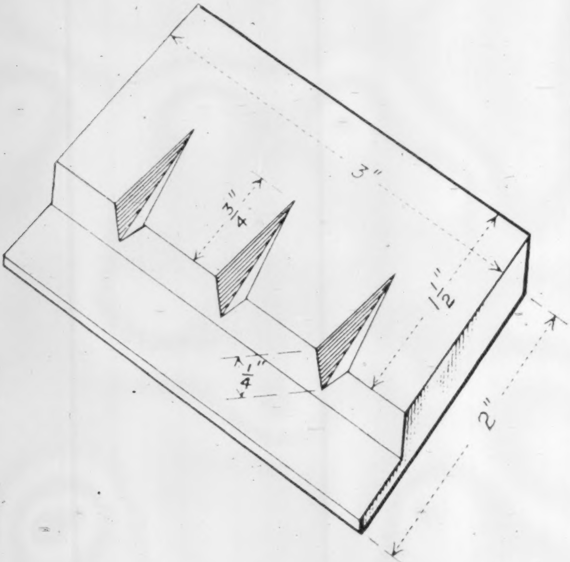

Fig. 3.—Brass Cone Mold.

Brass Cone Mold.—A brass cone mold for making ash cones, $\frac{3}{4}$ in. high and $\frac{1}{4}$ in. at each side of base, which is an equilateral triangle, is illustrated in Fig. 3.

Pyrometer.—Temperature measurements may be made with a thermocouple of platinum and platinum-rhodium, protected from the furnace gases by a glazed Marquadt, Usalite, Impervite or equal quality porcelain tube, and a high-resistance millivoltmeter; or with an optical pyrometer preferably of the

Leeds and Northrup, or Wanner type. This equipment should be checked frequently by mounting small pieces of pure gold or nickel wire or foil in the same manner as the cones. With a strong reducing atmosphere 1452° C. should be obtained for the melting point of the nickel and 1063° C. for the gold. The pyrometer equipment should also from time to time be standardized through the temperature range for which it is used, by a suitably equipped standardizing laboratory such as that of the United States Bureau of Standards.

PREPARATION OF COAL ASH.

Spread out 50 to 100 g. of 60-mesh coal on a 6-in. fire-clay roasting dish, and completely convert to ash in a muffle furnace at a temperature of 800 to 900° C. Transfer 5 to 10 g. of this ash to an agate mortar[1] and grind to a fineness of 200 mesh. Then place the ash in a silica or porcelain capsule, $\frac{5}{8}$ in. deep and $1\frac{3}{4}$ in. in diameter, and ignite for a period of two hours in a current of oxygen, at a temperature of 800 to 850° C. This ignition is made to insure complete and uniform oxidation of the ash.

PREPARATION OF CONES.

Moisten the ignited ash with a 10-per-cent dextrin solution and work into a plastic mass with a spatula. Mold the plastic material into small triangular pyramids $\frac{3}{4}$ in. high and $\frac{1}{4}$ in. wide at the side of the base. The pyramids are made by firmly pressing the plastic material with a steel spatula into a brass mold of the dimensions mentioned, the mold being similar to that shown in Fig. 3. Strike off the surface smooth and remove the cone from the mold by applying a small knife blade at the base. Mount the cones when dry in a refractory base composed of a mixture of equal parts of kaolin and calcined alumina. Moisten the base mixture to make it workable, and spread a part of it out on a sheet-iron plate. Then mount the cone in a vertical position in a small hole made in the base, and put base material into the hole around the bottom of the cone to fill the crevices and make the cone stand firmly. Usually five cones are mounted in one base in the manner shown in Fig. 4. Dry the sheet-iron plate with the test piece on a hot plate. Ignite the cones at a dull red heat for 30 minutes in an open muffle to remove the carbonaceous material.

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[1] A mechanical agate-mortar grinder will save time where many determinations are made.

METHOD OF HEATING.

Place the test piece in the muffle crucible of the melter's furnace in the position shown in Fig. 2, place the loosely fitting cover *g* on the crucible, and ignite the gas. It is necessary to let the gas burn about 10 minutes to heat the furnace parts before the large cover plate of the furnace is replaced; otherwise the flame is apt to blow out. During this time increase the flow of gas and air sufficiently to cause the combustion to take place just above the tuyeres and yet maintain a yellowish flame at least 6 in. above the opening in the furnace cover plate. While such a flame is maintained above the furnace gradually increase the temperature by a suitable adjustment of gas and air to 800° C., then reduce the rate of heat increase to not less than 5° C. and not more than 10° C. per minute. Maintain this rate until the end of the test. It is also important that the 6 in. reducing flame be maintained at the furnace vent throughout the test, if possible, and at all events up to a temperature of 1450° C. Temperatures above 1450° C. require larger proportions of air to gas; however, a strongly reducing atmosphere is not so essential at the higher temperatures, as refractory ashes, owing

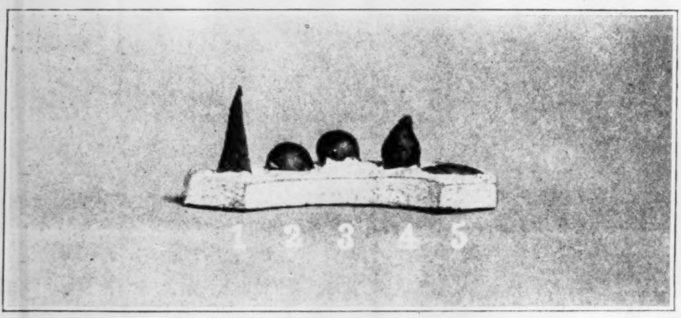

FIG. 4.—Typical Forms of Cones Fused in the No. 3 Melter's Furnace.

to their low iron-oxide content, are only slightly affected by oxidizing or reducing atmospheres. After a test has been completed, turn the supply of gas and air off gradually to avoid cracking the muffle crucible.

The softening temperature is defined as the temperature at which the cone has fused down to a spherical lump, as shown in cones 2 and 3 of Fig. 4. Cone 4 has almost reached the softening temperature.

The permissible differences of the softening temperature point in duplicate determinations are as follows:

Same analyst	30° C.
Different analysts	50° C.

NOTES.

Critical points other than the softening temperature, that may be observed during the test, and which may be of value are as follows:

The Initial Deformation Temperature.—The temperature at which the first rounding or bending of the apex of the cone takes place, as shown in cone 1 of Fig. 4. Such bending must not be confused with a shrinking or warping of the cone.

The Fluid Temperature.—The temperature at which the cone has spread out over the base in a flat layer, as represented by cone 5 of Fig. 4.

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TENTATIVE METHODS
FOR
TESTING TEXTILES.[1]

Serial Designation: D 76 – 20 T.

These methods are issued under the fixed designation D 76; the final number indicates the year of original issue, or in the case of revision, the year of last revision.

ISSUED, 1920.

Type of Machine. 1. Textile testing machines shall be of the inclination balance or pendulum type.

Testing Machine Capacity. 2. In selecting the proper capacity of testing machine for a given fabric, it is recommended that the maximum capacity of the machine shall conform to the following:

BREAKING STRENGTH OF FABRIC, LB.	MAXIMUM MACHINE CAPACITY, LB.
0 – 25	50
10 – 50	100
20 – 100	150
50 – 200	300
50 – 300	400
250 – 650	800

Angle of Pendulum. 3. The maximum angle of swing of the pendulum shall be 40 deg. from the vertical.

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[1] Criticisms of these Tentative Methods are solicited and should be directed, preferably before January 1, 1921, to Mr. A. E. Jury, Chairman of Committee D-13 on Textile Materials 1790 Broadway, New York City.

Rate of Loading

4. The rate of loading in textile testing machines shall be 250 lb. per 1 in. of traverse of the head jaw.

Type of Jaw.

5. The jaws in textile testing machines shall be of the flat anvil type, both anvils being free to swing on a horizontal axis. The anvil faces shall be smooth and no friction cloth shall be used. The anvils shall be closed at a uniform and invariable pressure by means of an eccentric and lever.

Crimp.

6. Crimp shall be defined as the difference in distance between any two points on a yarn in a fabric and the same two points after the yarn has been removed and straightened. This difference shall be reduced to percentage of the yarn length as it lies in the fabric.

Off-square.

7. The percentage of warp crimp minus the percentage of filling crimp shall be defined as the off-square of the fabric.

Method of Determining Crimp in Tire Fabric.

8. Threads for crimp test of tire fabric shall be taken from the inside edge of test piece as near the center line of the roll as possible. Threads for crimp test shall be laid out by marking across them in the fabric parallel lines not less than 6 in. apart. An even number of threads not less than four in number shall be taken for each warp and each filling test. These threads shall be ravelled from the fabric after marking, allowing about 2 in. extra on each end of the threads beyond the marks. The threads shall then be straightened by a machine which applies a constant load of 75 g. and the length between the original markings shall then be read in terms of the yarn length as it lay in the fabric. The machine shall be equipped with a dial or scale so arranged as to read the percentage crimp directly.

TENTATIVE REVISIONS
OF
A.S.T.M. STANDARDS

Tentative Revisions of A.S.T.M. Standards are printed for one or more years with a view of eliciting criticisms, of which the committee concerned will take due cognizance before recommending final action.

Members of the Society and others are invited to direct written criticisms of any of these Tentative Revisions to the officer of the appropriate committee, whose name and address appear in the footnote in connection with each revision.

TENTATIVE REVISIONS OF A.S.T.M. STANDARDS.

A. FERROUS METALS.

STANDARD SPECIFICATIONS FOR OPEN-HEARTH STEEL GIRDER AND HIGH TEE RAILS.

(SERIAL DESIGNATION: A 2–12).[1]

Omit Sections 7 to 10, inclusive, and substitute the following Sections 7 to 9, renumbering the remaining sections of the specifications:

Impression Test Specimens.

7. (*a*) Four representative sections of rail from each melt shall be selected by the inspector as test specimens.

(*b*) Excess scale on the head of the section shall be carefully removed.

Impression Test.

8. (*a*) The head of each specimen shall be subjected to a pressure of 50 net tons (100,000 lb.) for a period of 15 seconds, applied through a ball $\frac{3}{4}$ in. in diameter.

(*b*) The average depth of impression obtained on the four specimens shall not be more than 3.8 mm. for Class A rails, nor more than 3.6 mm. for Class B rails.

Retests.

9. If the average of the impression tests from any melt fails to conform to the requirements specified in Section 8 (*b*), the manufacturer may at his option test each rail from such melt by making an impression test on the web, as described in Section 8 (*a*). Rails so tested which conform to the requirements as to depth of impression specified in Section 8 (*b*) shall be accepted.

STANDARD SPECIFICATIONS FOR QUENCHED HIGH-CARBON-STEEL SPLICE BARS.

(SERIAL DESIGNATION: A 49 – 15).[1]

Section 11.—Change to read as follows by the addition of the italicized words and the omission of the words in brackets:

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[1] 1918 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. F. M. Waring, Chairman of Committee A-1 on Steel, Pennsylvania System, Altoona, Pa.

"If the results of the physical tests of any test lot do not conform to the requirements specified, [the manufacturer may re-treat such lot one or more times and retests shall be made as specified in Section 10.] *two additional tension and two additional bend tests shall be made from such lot, all of which shall conform to the requirements specified.*"

STANDARD SPECIFICATIONS FOR QUENCHED CARBON-STEEL TRACK BOLTS.

(SERIAL DESIGNATION: A 50 – 16).[1]

Section 11.—Change to read as follows:

"The bolts and nuts shall conform to the dimensions specified by the purchaser. They shall be neatly formed and free from fins or nicking. The head of the bolt shall be concentric with and firmly joined to the shank, with the underside at right angles to the axis of the bolt. The threads shall be sharp and true to gage and of the design specified by the purchaser. The nuts shall have a hand free fit on the bolt from two to six turns, and wrench tight the balance of the screw length without distorting the threads or twisting the shank. They shall be screwed on the bolts before packing, a sufficient number of turns to hold them in place until used. A variation of $\frac{1}{32}$ in. under and $\frac{1}{64}$ in. over the specified diameter of the shank of the bolt will be permitted. The diameter of rolled thread shall not exceed the diameter of the shank more than $\frac{1}{16}$ in. for bolts $\frac{7}{8}$ in. in diameter and under, nor more than $\frac{3}{32}$ in. for bolts 1 in. in diameter and over. The outside diameter of the finished rolled thread shall not exceed the diameter of the shank of a cut thread bolt of corresponding size. The length of the bolt under the head shall not vary more than $\frac{1}{8}$ in. from that specified. A variation in the dimensions of the elliptical shoulders under the head of $\frac{1}{32}$ in. and a taper of the shoulder of $\frac{1}{32}$ in. will be permitted."

STANDARD SPECIFICATIONS FOR QUENCHED ALLOY-STEEL TRACK BOLTS.

(SERIAL DESIGNATION: A 51 – 16).[1]

Section 11.—Make the same change as in Section 11 of Specifications A 50 – 16 above.

STANDARD SPECIFICATIONS FOR STEEL SCREW SPIKES.

(SERIAL DESIGNATION: A 66 – 18).[1]

Section 7.—Change the fifth sentence to read as follows by the omission of the words in brackets:

"A variation of $\frac{1}{32}$ in. over [and under] the specified diameter of the unthreaded portion of the body of the spike will be permitted."

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[1] 1918 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. F. M. Waring, Chairman of Committee A-1 on Steel, Pennsylvania System, Altoona, Pa.

STANDARD SPECIFICATIONS FOR STRUCTURAL STEEL FOR BRIDGES.

(SERIAL DESIGNATION: A 7 – 16).[1]

Insert the provision in the appropriate place that:

"Tension and bend test specimens for rivet bars which have been cold drawn shall be normalized before testing."

STANDARD SPECIFICATIONS FOR STRUCTURAL NICKEL STEEL.

(SERIAL DESIGNATION: A 8 – 16).[1]

Insert the provision in the appropriate place that:

"Tension and bend test specimens for rivet bars which have been cold drawn shall be normalized before testing."

STANDARD SPECIFICATIONS FOR STRUCTURAL STEEL FOR BUILDINGS.

(SERIAL DESIGNATION: A 9 – 16).[1]

Insert the provision in the appropriate place that:

"Tension and bend test specimens for rivet bars which have been cold drawn shall be normalized before testing."

STANDARD SPECIFICATIONS FOR STRUCTURAL STEEL FOR LOCOMOTIVES.

(SERIAL DESIGNATION: A 10 – 16).[1]

Section 6.—Add a sentence to read as follows:

"Plates $\frac{3}{16}$ in. or under in thickness shall not be subject to tension tests."

STANDARD SPECIFICATIONS FOR STRUCTURAL STEEL FOR CARS.

(SERIAL DESIGNATION: A 11 – 16).[1]

Insert the provision in the appropriate place that:

"Tension and bend test specimens for rivet bars which have been cold drawn shall be normalized before testing."

Section 6.—Make the same change as in Section 6 of Specifications A 10–16 above.

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[1] 1918 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. F. M. Waring, Chairman of Committee A-1 on Steel, Pennsylvania System, Altoona, Pa.

STANDARD SPECIFICATIONS FOR RIVET STEEL FOR SHIPS.

(SERIAL DESIGNATION: A 13 - 14).[1]

Insert the provision in the appropriate place that:

"Tension and bend test specimens for rivet bars which have been cold drawn shall be normalized before testing."

STANDARD SPECIFICATIONS FOR BOILER RIVET STEEL.

(SERIAL DESIGNATION: A 31 - 14).[1]

Insert the provision in the appropriate place that:

"Tension and bend test specimens for rivet bars which have been cold drawn shall be normalized before testing."

STANDARD SPECIFICATIONS FOR LAP-WELDED AND SEAMLESS STEEL BOILER TUBES FOR LOCOMOTIVES.

(SERIAL DESIGNATION: A 28 - 18).[1]

1. *Section 6*.—Omit the word "small" before "tubes" in Paragraphs (*a*) and (*b*). In Paragraph (*a*) omit the comma after the word "pipes."

2. *Section 14* (*a*).—Change from its present form, namely:

"The finished tubes shall be circular within 0.02 in., and the mean outside diameter shall not vary more than 0.015 in. from the size ordered.",

to read as follows:

"Finished tubes 3½ in. or under in outside diameter shall be circular within 0.02 in. and the mean outside diameter shall not vary more than 0.015 in. from the size ordered. For tubes over 3½ in. in outside diameter, these variations shall not exceed 0.5 per cent of the outside diameter."

STANDARD SPECIFICATIONS FOR WELDED STEEL PIPE.

(SERIAL DESIGNATION: A 53 - 18).[1]

These specifications have been extensively revised and are published in their proposed revised form as tentative specifications.[2]

STANDARD SPECIFICATIONS FOR AUTOMOBILE CARBON AND ALLOY STEELS.

(SERIAL DESIGNATION: A 29 - 18).[1]

1. Change the permissible range in chromium in the first three classes in Table IV on Automobile Chromium Steels from

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[1] 1918 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. F. M. Waring, Chairman of Committee A-1 on Steel, Pennsylvania System, Altoona, Pa.

[2] See p. 487.

0.65–0.85 to 0.60–0.90 per cent, leaving the desired chromium 0.75 per cent as before.

2. Omit the fourth, fifth and seventh classes in the table and substitute therefor the following fully representative type of oil-quenching chromium steel:

	DESIRED.	PERMISSIBLE RANGE
Carbon, per cent	1.00	0.95 – 1.10
Manganese, "	0.35	0.20 – 0.50
Phosphorus, "		not over 0.03
Sulfur, "		" " 0.03
Chromium, "	1.35	1.20 – 1.50

STANDARD SPECIFICATIONS FOR ENGINE-BOLT IRON.

(SERIAL DESIGNATION: A 40–18).[1]

Section 1.—Change to read as follows by the addition of the italicized words:

> "The iron shall be made from *all pig* puddled iron and shall be free from any admixture of iron scrap or steel."

STANDARD SPECIFICATIONS FOR WELDED WROUGHT-IRON PIPE.

(SERIAL DESIGNATION: A 72 – 18).[1]

It is recommended that Table I on Hydrostatic Pressures and Table II on Standard Weights be revised to conform to the tables as printed herewith.[2]

STANDARD SPECIFICATIONS FOR STAYBOLT IRON.

(SERIAL DESIGNATION: A 39 – 18).[1]

Section 10.—Change to read as follows by the addition of the italicized figures and the omission of the figures in brackets:

> "The bars shall be truly round within 0.01 in. and shall not vary more than [0.005] *0.01* in. above nor more than [0.01] *0.005* in. below the specified size."

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[1] 1918 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. J. B. Young, Secretary of Committee A-2 on Wrought Iron, Philadelphia and Reading Railway Co., Reading, Pa.

[2] See pp. 814–815.

TABLE I.—HYDROSTATIC PRESSURES FOR WELDED PIPE.

(Pressures Expressed in Pounds per Square Inch)

(BLACK AND GALVANIZED)

Size, (Nominal Inside Diameter), in.	"Standard" Pipe.			"Extra Strong" Pipe.		
	Weight of Pipe per Linear Foot, Threaded and with Couplings, lb.	Butt-Weld.	Lap-Weld.	Weight of Pipe per Linear Foot, Plain Ends, lb.	Butt-Weld.	Lap-Weld.
$\frac{1}{8}$	.....	700	....	.....	700	....
$\frac{1}{4}$	.....	700	....	.....	700	....
$\frac{3}{8}$	.....	700	....	.....	700	....
$\frac{1}{2}$	.....	700	....	.....	700	....
$\frac{3}{4}$	.....	700	....	.....	700	....
1	.....	700	....	.....	700	....
$1\frac{1}{4}$	.....	700	1000	.....	1500	2500
$1\frac{1}{2}$	.....	700	1000	.....	1500	2500
2	.....	700	1000	.....	1500	2500
$2\frac{1}{2}$	.....	800	1000	.....	1500	2000
3	.....	800	1000	.....	1500	2000
$3\frac{1}{2}$	.....	...	1000	.....	....	2000
4	.....	...	1000	.....	....	2000
$4\frac{1}{2}$	.....	...	1000	.....	....	1800
5	.....	...	1000	.....	....	1800
6	.....	...	1000	.....	....	1800
7	.....	...	1000	.....	....	1500
8	25.00	...	800	.....	....	....
8	28.81	...	1000	43.39	....	1500
9	34.19	...	900	48.73	....	1200
10	32.00	...	600	.....	....	....
10	35.00	...	700	.....	....	....
10	41.13	...	900	54.74	....	1000
11	46.25	...	800	60.08	....	1000
12	45.00	...	600	.....	....	....
12	50.71	...	800	65.42	....	1000

For pipes over 12 in. in insidediameter, the test pressures should be calculated by the formula $P = \frac{2\,St}{D}$ in which P = pressure in pounds per square inch; S = fiber stress = 12,000 lb. per sq. in.; t = thickness of wall in inches; D = inside diameter in inches.

TABLE II.—WEIGHTS OF STANDARD WELDED PIPE.

(BLACK AND GALVANIZED)

Size (Nominal inside Diameter), in.	"Standard" Pipe.				"Extra Strong" Pipe.	
	Outside Diameter, in.	Number of Threads per Inch.	Thickness, in.	Weight of Pipe per Linear Foot, Threaded and with Couplings, lb.	Thickness, in.	Weight of Pipe per Linear Foot, Plain Ends, lb.
$\frac{1}{8}$	0.405	27	0.068	0.25	0.095	**0.31**
$\frac{1}{4}$	0.540	18	0.088	0.43	0.119	**0.54**
$\frac{3}{8}$	0.675	18	0.091	0.57	0.126	**0.74**
$\frac{1}{2}$	0.840	14	0.109	0.85	0.147	**1.09**
$\frac{3}{4}$	1.050	14	0.113	1.13	0.154	**1.47**
1	1.315	$11\frac{1}{2}$	0.133	1.68	0.179	**2.17**
$1\frac{1}{4}$	1.660	$11\frac{1}{2}$	0.140	2.28	0.191	**3.00**
$1\frac{1}{2}$	1.900	$11\frac{1}{2}$	0.145	2.73	0.200	**3.63**
2	2.375	$11\frac{1}{2}$	0.154	3.68	0.218	5.02
$2\frac{1}{2}$	2.875	8	0.203	5.82	0.276	7.66
3	3.500	8	0.216	7.62	0.300	10.25
$3\frac{1}{2}$	4.000	8	0.226	9.20	0.318	12.51
4	4.500	8	0.237	10.89	0.337	14.98
$4\frac{1}{2}$	5.000	8	0.247	12.64	0.355	17.61
5	5.563	8	0.258	14.81	0.375	20.78
6	6.625	8	0.280	19.19	0.432	28.57
7	7.625	8	0.301	23.77	0.500	38.05
*8	8.625	8	0.277	25.00	.....	.....
8	8.625	8	0.322	28.81	0.500	**43.39**
9	9.625	8	0.342	34.19	0.500	**48.73**
*10	10.750	8	0.279	32.00	.....	.....
*10	10.750	8	0.307	35.00	.....	.....
10	10.750	8	0.365	41.13	0.500	**54.74**
11	11.750	8	0.375	46.25	0.500	60.08
*12	12.750	8	0.330	45.00	.....	.....
12	12.750	8	0.375	50.71	0.500	**65.42**

* Unless specifically stated on the order the lighter weights will not be furnished. Weights given in the table are for pipes up to and including 12 in. in nominal inside diameter, with threaded ends and couplings; sizes larger than shown in the table are measured by the outside diameter and usually have plain ends; for such sizes it will be necessary to accept Manufacturers' weights or calculate the weights on the basis of one cubic inch of iron or steel weighing 0.2833 lb.

B. NON-FERROUS METALS.

STANDARD SPECIFICATIONS FOR SPELTER.

(SERIAL DESIGNATION: B 6 – 18).[1]

A revision in the nature of a separation of a portion of these specifications and publication under the title "Methods for Analysis of Spelter" is intended to be made in the 1921 Book of A.S.T.M. Standards.

STANDARD SPECIFICATIONS FOR COPPER BARS FOR LOCOMOTIVE STAYBOLTS.

(SERIAL DESIGNATION: B 12 – 18).[1]

Section 9.—Change to read as follows by the addition of the figures in italics and the omission of the figures in brackets:

"The bars shall be truly round within 0.01 in., and shall not vary more than [0.005] *0.01* in. above nor more than [0.01] *0.005* in. below the specified size."

C. CEMENT, LIME, GYPSUM, AND CLAY PRODUCTS.

STANDARD SPECIFICATIONS FOR HYDRATED LIME.

(SERIAL DESIGNATION: C 6 – 15).[2]

A revision in the form of a separate tentative specification entitled "Specifications for Hydrated Lime (C 6 – 19 T)"[3] is intended to replace the present standard specifications.

STANDARD SPECIFICATIONS AND TESTS FOR PORTLAND CEMENT.

(SERIAL DESIGNATION: C 9 – 21).[4]

A revision in the form of a separate tentative specification entitled "Specifications for Compressive Strength of Cement Mortars (C 9 – 16 T)"[5] is intended to become a part of the present standard specifications.

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[1] 1918 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. William Campbell, Chairman of Committee B-2 on Non-Ferrous Metals and Alloys, Columbia University, New York City.

[2] 1918 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. D. K. Boyd, Chairman of Committee C-7 on Lime, 1701 Walnut St., Philadelphia, Pa.

[3] See p. 605.

[4] C 9 – 17, 1918 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. P. H. Bates, Secretary of Committee C-1 on Cement, Bureau of Standards, Washington, D. C.

[5] See p. 599.

STANDARD SPECIFICATIONS FOR DRAIN TILE.

(SERIAL DESIGNATION: C 4 - 16).[1]

1. *Section 6.*—Change the first sentence to read as follows by the addition of the italicized words and the omission of the words in brackets:

> "The purchaser may [prescribe in advance] *specify* special chemical requirements *as to resistance of the tile to chemical action* in cases where *soils or* drainage waters have marked acid or alkaline character, or are of abnormally high temperature, and may [use] *prescribe* chemical [analysis] *tests* of the tile to ascertain whether these special requirements are met."

2. *Section 26.*—Change to read as follows by the addition of the italicized words and omission of the words in brackets:

> "The test specimens employed in making [the absorption test shall preferably be used for] the freezing and thawing test [. In the event that the same specimens are not available], *shall be* another set selected as specified in Section 21."

3. *Section 27.*—Change to read as follows by the addition of italicized words and the omission of the words in brackets:

> "[In the event that new specimens for the freezing and thawing test must be prepared, they] *The specimens* shall be dried as specified in Section 22."

4. *Section 29.*—Change to read as follows by the addition of the italicized words and the omission of the words in brackets:

> "[In the event that new specimens for the freezing and thawing test must be prepared, they] *The specimens* shall be immersed [and boiled and cooled] *for 72 hours* in water [as specified in Section 24.] *having a temperature of 18 to 24° C. (65 to 75° F.) and then weighed as specified in Section 23.*"

5. *Section 30.*—Change the third paragraph to read as follows by the addition of the italicized words and figures and the omission of the words and figures in brackets:

> "At the conclusion of freezing under the specified conditions, the crate of specimens shall be withdrawn and at once immersed in water at a temperature of [85] *18* to [100°] *24°* C.([185] *65* to [212°] *75°* F.) in a

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[1] 1918 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. A. Marston, Chairman of Committee C-6 on Drain Tile, Iowa State College, Ames, Ia.

special receptacle of proper size. Heating shall be continued so that the water will regain the required temperature as soon as practicable after the specimens are immersed. A temperature of [85] *18* to [100°] *24*° C. ([185] *65* to [212°] *75*° F.) shall then be maintained for not less than [15 minutes] ***2 hours***. At the conclusion of the thawing treatment the crate shall be [cooled down rapidly in water to 10 to 15° C. (50 to 59° F.) and then] inspected [. The] ***and the*** condition of each sample after each thawing shall be noted in the records."

6. *Table I.*—Change the note at the bottom of Table I to read as follows by the addition of the italicized words and the omission of the words in brackets:

> "When the freezing and thawing test is [specified or demanded] *made* as provided in Section 7, the number of freezings and thawings to be endured shall be as follows: For farm drain tile [8] *24;* for standard drain tile, [12] *36;* for extra-quality drain tile, [16] *48*."

STANDARD METHODS FOR ULTIMATE CHEMICAL ANALYSIS OF REFRACTORY MATERIALS.

(SERIAL DESIGNATION: C 18 – 20).[1]

A revision in the form of a separate tentative method entitled "Method for Ultimate Chemical Analysis of Chrome Ores and Chrome Brick (C 18 – 20 T)"[2] is intended to become a part of the present standard methods.

D. MISCELLANEOUS MATERIALS.

STANDARD SPECIFICATIONS FOR TURPENTINE.

(SERIAL DESIGNATION: D 13 – 15).[3]

A revision in the form of a separate specification entitled "Specification for Turpentine (D 13 – 20 T)"[4] is intended to replace the present standard specifications.

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[1] A.S.T.M. Standards adopted in 1920. Criticisms of this revision are solicited and should be directed to Mr. A. V. Bleininger, Chairman of Committee C-8 on Refractories, Bureau of Standards, Washington, D. C.

[2] See p. 647.

[3] 1918 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. R. L. Hallett, Secretary of Committee D-1 on Preservative Coatings for Structural Materials, 129 York St., Brooklyn, N. Y.

[4] See p. 680.

STANDARD SPECIFICATIONS FOR 2½-IN. COTTON RUBBER-LINED FIRE HOSE FOR PRIVATE DEPARTMENT USE.

(Serial Designation: D 14–15).[1]

1. *Section 1* (*b*).—Omit the first two sentences and change the third sentence to read as follows by the addition of the italicized words and the omission of the words in brackets:

> "(*b*) Sizing or other treatment liable to cause mildew shall [be avoided] *not be used*."

2. *Section 2* (*e*).—Change to read as follows by the addition of the italicized words and the omission of words in brackets:

> "(*e*) The lining (without cement [and] *or* backing) shall be made up of not less than three calendered sheets, and shall be not less than [0.049] *0.050 nor more than 0.060* in. in thickness [, and, including cement and other backing, shall not exceed 0.076 in. in thickness]. *Soft rubber backing shall not exceed 0.025 in. in thickness.*

3. *Section 10* (*c*).—Change the minimum requirement of copper for couplings from 82 to 83 per cent.

STANDARD SPECIFICATIONS FOR 2½, 3 AND 3½-IN. DOUBLE-JACKETED COTTON RUBBER-LINED FIRE HOSE FOR PUBLIC FIRE DEPARTMENT USE.

(Serial Designation: D 26–18).[1]

Section 10 (*c*).—Change the minimum requirement of copper for couplings from 82 to 83 per cent.

STANDARD SPECIFICATIONS FOR PURITY OF RAW TUNG OIL.

(Serial Designation: D 12 – 16).[2]

1. *Section 1.*—In the table of properties, omit the words "Browne's Method" after "Heating Test;" and omit the line "Iodine Jelly Test, minutes . . . . . . 4."

2. Replace the description of the Heating Test (Browne's Method) by the following:

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[1] 1918 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. F. M. Farmer, Chairman of Committee D-11 on Rubber Products, Electric Testing Laboratories, Eightieth and East End Ave., New York City.

[2] 1918 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. R. L. Hallett, Chairman of Committee D-1 on Preservative Coatings for Structural Materials, 129 York St., Brooklyn, N. Y.

Heating Test.—Test tubes containing the oil should be 15 cm. by 16 mm., with a mark near the bottom to indicate 5 cc., and closed by a cork so perforated that a glass rod 3 mm. in diameter can move freely.

Fill an 800-cc. glass beaker (height, 15 cm.; diameter, 10 cm.), with cottonseed oil or soya bean oil to a height of 7.5 cm. Place a thermometer so as to be 1.5 cm. from the bottom of the bath. (See Fig. 1.)

Use a nitrogen-filled, chemical thermometer; engraved stem; total length 4 to 4½ in., graduated from 210 to 310° C. in 2° intervals; the length between 210 and 310° C. not less than 2½ in. Thermometer glass shall be well annealed.

When the bath temperature is 293° C. (560° F.) and very slowly rising at this point, place the tube containing 5 cc. of the oil to be tested and the tube containing 5 cc. of the control sample, so that the bottom of each tube is level with the lowest part of the bulb of the thermometer. If desired, the collars *C* may be omitted and the tubes allowed to rest upon a piece of wire gauze placed in the bottom of the oil bath so that the tubes will be 1.5 cm. from the bottom of the bath. Note the time. Remove the source of heat for about 45 seconds and then reapply. Before 2 minutes have elapsed the temperature of the bath will have fallen to 282° C. (540° F.), at which point it should be kept as steady as possible. When the samples have been in the bath 9 minutes, raise the glass rods at intervals of ¼ minute. Note the time when each sample becomes firmly set. At this period the oil will be so stiff that the entire tube may be lifted by aid of the rod if the collar *C* is omitted from the apparatus. As setting or jellying takes place within a few seconds of fluidity, a good end determination is afforded. Remove the specimens. Heat the bath again to 293° C., and repeat the experiment with fresh portions of the sample.

No stirrer is used in the bath. A screen around the bath enables the temperature to be more easily reached. When the bath oil has become tarry and viscid, it should be renewed; otherwise heating may be irregular.

3. Omit the description of the Iodine Jelly Test.

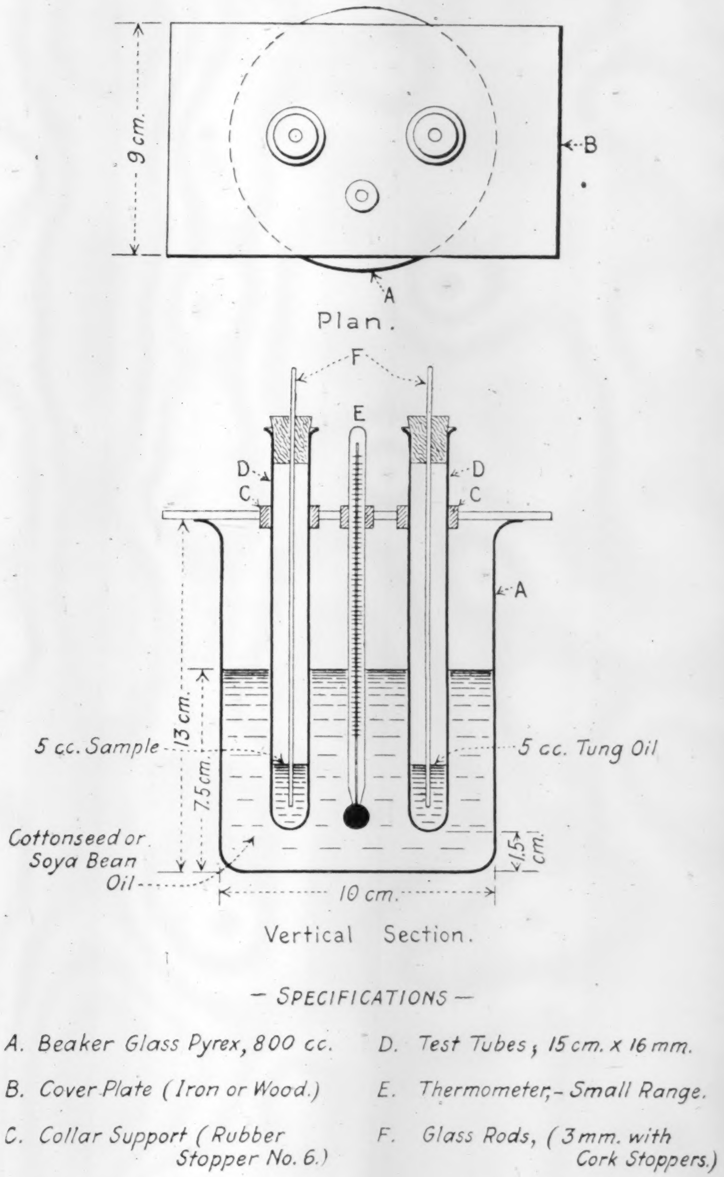
9 cm.
B
A
Plan.
F
E
D
D
C
C
A
13 cm.
7.5 cm.
5 cc. Sample
5 cc. Tung Oil
Cottonseed or Soya Bean Oil
1.5 cm.
10 cm.
Vertical Section.
— SPECIFICATIONS —
A. Beaker Glass Pyrex, 800 cc.
B. Cover Plate (Iron or Wood.)
C. Collar Support (Rubber Stopper No. 6.)
D. Test Tubes; 15 cm. x 16 mm.
E. Thermometer, - Small Range.
F. Glass Rods, (3 mm. with Cork Stoppers.)

FIG. 1.—Tung Oil Heat Test Apparatus (Revised 1920).

NOTE: Collars *C* may be omitted and tubes supported in present place by aid of wire gauze placed in bottom of oil bath and resting on bottom of beaker.

STANDARD METHODS FOR LABORATORY SAMPLING AND ANALYSIS OF COAL.

(SERIAL DESIGNATION: D 22 - 16).[1]

Under Apparatus (page 681, line 6) change "An 8-in. 60-mesh Sieve with Cover and Receiver" to read: "An 8-in. No. 60 Bureau of Standards Standard Screen Scale Sieve with Cover and Receiver."

A revision in the form of a separate tentative method entitled "Method for Determination of Fusibility of Coal Ash (D 22 - 19 T)"[2] is intended to become a part of the present standard methods.

STANDARD METHODS FOR LABORATORY SAMPLING AND ANALYSIS OF COKE.

(SERIAL DESIGNATION: D 37 - 18).[3]

Under Apparatus (page 710, line 4) change "An 8-in. 60-mesh Sieve with Cover and Receiver" to read: "An 8-in. No. 60 Bureau of Standards Standard Screen Scale Sieve with Cover and Receiver."

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[1] 1918 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. A. C. Fieldner, Chairman of Committee D-3 on Methods of Sampling and Analysis of Coal, Fortieth and Butler Sts., Pittsburgh, Pa.

[2] See p. 796.

[3] 1918 Book of A.S.T.M. Standards. Criticisms of this revision are solicited and should be directed to Mr. A. C. Fieldner, Secretary of Committee D-6 on Coke, Fortieth and Butler Sts., Pittsburgh, Pa.

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